ENGLISH PUBLIC HEALTH SERIES

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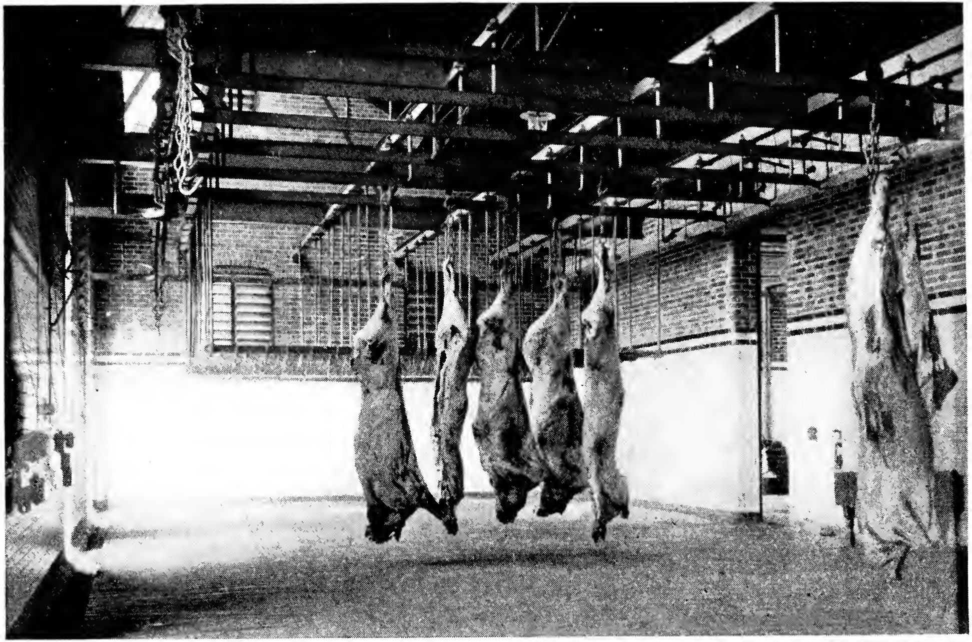
FOOD AND THE PUBLIC HEALTH



Separate cooling-room of a properly constructed slaughter-house (Weston-super-Mare Public Abattoir).

PLATE I.

Food and the Public Health

BY

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WITH EIGHT HALF-TONE PLATES

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PREFACE

WITHOUT knowledge there can be no real progress. With partial and inaccurate knowledge progress may result, but is likely to be halting, limited and misdirected.

There are few subjects which the general public, and those who advise and form public opinion, are so much interested as in that of food. Unfortunately, much of the information which reaches the public is unbalanced and unequal in its presentation.

Founts of truth there are in plenty in the numerous excellent textbooks on the subject, but their technicalities obscure the truth for those who do not hold the key. This little book is written in language as little technical as possible so that all who will may acquire a clear and balanced knowledge of food in its relation to the health of the community.

I am greatly indebted to Dr. Hope, Medical Officer of Health of Liverpool, for allowing me to use Plates II., VI., and VIII. from his valuable collection; to Messrs. Macmillan & Co. for permitting me to copy Plates III. and V. from my

book "Milk and the Public Health," published by them, and to Dr. Lauder for permission to reproduce Plate IV., which illustrates the instructive paper by him and Mr. Cunningham on "Some Factors affecting the Bacteriological Content of Milk."

W. G. S.

CONTENTS

Contents

Contents

LIST OF HALF-TONE PLATES

FOOD AND THE PUBLIC HEALTH

CHAPTER I

Food Generally as a Cause of Ill-Health or Disease

MAN needs but little here below (whatever he may want), but of these needs food is an essential, and variations in its quality and quantity rapidly produce an effect upon health.

How health is affected by food. — It will clarify the subject to set out the different ways in which health may be affected through food.

1. The food may be wrong in quantity as a whole or wrong as regards the relative proportions of its different constituents.

2. The food may be naturally poisonous, being derived from plants or animals which under ordinary conditions contain substances inimical to man.

3. The food may be a cause of disease because derived from plants or animals which are attacked

by diseases capable of being conveyed through food to man. The cause of these diseases may be vegetable parasites such as ergot, animal parasites such as tapeworms, bacterial parasites like the bacteria of tuberculosis and anthrax.

4. The food may originate from healthy sources but become contaminated subsequently with animal parasites or harmful bacteria.

5. The food may be prejudicial because it has become mixed with chemical substances which are harmful. The addition may be accidental, like tin from canned foods, or deliberate as when chemicals are added as food preservatives.

Summarised, the above resolve themselves into defects of quantity (as a whole or of individual constituents), inherently poisonous constituents, or infection or admixture with harmful foreign bodies —animal or vegetable parasites, bacteria, chemical substances.

The prejudicial effects from admixture with harmful foreign bodies are considered in the following chapters; the other two sources of ill-health are dealt with in the present chapter.

Food is necessary for growth, maintenance of the tissues and making up for wear and tear, to keep up the body temperature and to supply the energy necessary to enable work to be performed. It follows that the amount of food required by different individuals to maintain them in a healthy condition must vary widely since these factors vary

so greatly with different persons. The problem is complicated also by the fact that the ability to digest and so utilise food varies considerably, so that persons of very similar habits and energy needs may maintain their health upon very different quantities of food, even though their food contains approximately the same constituents. There are, however, certain minima and maxima which are generally applicable, but to understand these it will be necessary to explain something of the general composition of foods.

Classification of food constituents.—Nearly all the ordinary articles of diet are not simple bodies, but are made up of a mixture of different substances of varying degrees of utility to the body. But all the constituents of the innumerable varieties of foods can be grouped chemically into four classes. These are, inorganic salts, proteins, carbohydrates and fats; while, in addition, there are certain very important accessory substances called *vitamines* which can hardly be grouped as a class of foodstuffs. All foods consist of a mixture with water of one or more of these groups.

Of the *inorganic salts* and of water little need be said, except that they are essential and are abundantly present in ordinary diets. The extent to which a deficiency of a salt, such as iron or calcium, affects health is a subject of importance, but in regard to which our knowledge is not very definite. Any ill-health from their deficiency may

not be due to an insufficient supply in food, but may result from inadequate absorption from the intestine. It is popularly supposed that an excess of calcium salts from hard water or in foods leads to stone in the kidney, disease of the arteries, etc., but there is no reliable evidence of this. It is very doubtful if the intestine absorbs more calcium than is required.

A sufficiency of *proteins* in the diet is essential since they are the only form of food which contains nitrogen, and nitrogen is a constituent of every tissue in the body. The function of building up the tissues and of repairing them when wasted can only be fulfilled by the proteins, with the help of inorganic salts and, of course, water, White of egg and fat-free meat are mostly protein in nature, and all proteins are of great complexity of chemical structure. They all contain carbon, hydrogen and oxygen as well as nitrogen, while some of the many varieties contain also phosphorus and sulphur.

The *carbohydrates* (the sugars and starch) and the *fats* are both composed of compounds built up entirely of carbon, hydrogen and oxygen, but differ chemically in the relative proportions of these elements. In the carbohydrates the oxygen is always twice as much as the hydrogen, in the fats the proportion is less than this.

For the most part, carbohydrates and fats can replace one another in diets, but there must always

be enough protein to supply the nitrogen necessary. On the other hand, an excess of proteins—that is, more than requisite to maintain the equilibrium necessary for health—means that the body has to get rid of the excess of nitrogen beyond its needs, since proteins cannot be stored up in the body, and this throws a strain upon the organs of excretion (especially the kidneys) which, if long persisted in, may result in permanent injury.

To obtain a satisfactory diet involves an adjustment of a number of factors of which it is possible here to indicate only the outlines. A further factor is the energy yielded.

Calories.— Since the food is required to supply energy, calculations as to the amounts needed have to be converted, and considered in terms of the energy they will yield, and since energy and heat are interchangeable and bear an exact, invariable relation to one another, this energy is measured in terms of calories. A calorie is the quantity of heat energy required to raise the temperature of one kilogramme of water by one degree on the centigrade scale. The heat given off by food is something which can be definitely measured.

Careful estimations have shown that the calorie value of 1 gramme of each of the chief foodstuffs is:

Fat	9·3 calories
Carbohydrate	4.1 ,,
Protein	4·1 ,,

The amount of calories required will vary not only with the size of the individual, and to some extent with the temperature, but especially with the amount of work which has to be done. It is obvious that heavy muscular work involves a heavy expenditure of energy and necessitates food of a high calorific power. So large a portion of the food consumed is needed to keep up the body temperature that it is evident that in hot climates much less food is required and one of a lower value in calories.

Digestibility of foods. — Another factor which has to be taken into consideration in dietary framing is the digestibility of the food. Food is of no use to the body unless it can be converted by the digestive system into substances which can be absorbed into the blood, and so take part in the work of the body. From this point of view we must consider the alimentary canal as a convoluted tube of variable calibre running through the body, the contents of which are to all intents apart from the body structure and only of value when absorbed into it. With this simple conception in mind it is obviously of the first importance that food should be digestible, and also adapted to the digestive organs of the person eating or drinking it.

For example, green vegetables are bulky, and if we consider merely the amounts of nutritive elements contained in them or the amount of heat energy which it is possible to obtain from them

under the best conditions they would appear as highly nutritive foods. They, however, largely consist of cellulose, a most indigestible substance, little of which is broken down and absorbed. These foods are chiefly valuable for other purposes.

An illustration of the need to consider also the digestive capacity of the individual is furnished by the unsuitability of starchy foods for young infants. Starchy foods such as rice, bread, and potatoes are readily converted into sugar and so digested by adults and children, but in infants only a few months old the necessary digestive ferments are absent, and starch fed to them remains starch and is not absorbed at all, and is only comparable in suitability to a diet of indiarubber.

Common foods.—The composition of some of the more common foods as regards their percentage of protein, fat, and carbohydrate is shown in the table on p. 8.

Knowing the calories yielded by one gramme of protein, fat, or carbohydrate, it is easy to calculate the heat-producing value (calories) of any definite amount of food. This is shown in the last column of the table. An ounce is equal to 28.35 grammes.

The table shows that the animal foods are especially rich in proteins and fats, while vegetable foods are the chief source of carbohydrate. Certain vegetable foods however, such as peas, beans, and oatmeal, contain a high proportion of protein and

PERCENTAGE COMPOSITION OF FOODS *

The figures refer to foods as bought, all necessary waste being allowed for, except the bones in butcher's meat:—

Food	*Protein*	*Fat*	*Carbohydrate*	*Calories per oz.*
Wheat flour	11	1	75	103
Bread	8	1	52	74
Oatmeal	15	8	60	108
Rice	8	0	79	102
Beef (fat)	17	31	—	101
,, (medium fat)	15	18	—	65
Mutton	13	27	—	87
Bacon	10	60	—	169
Ham	14	33	—	104
Pork	10	40	—	117
Eggs	12	9	—	39
Rabbits	14	7	—	35
Cod, hake, etc.	10	1	—	14
Herring	11	4	—	23
Salmon	15	9	—	41
Milk	3	4	5	20
Butter	1	85	—	225
Margarine	1	84	—	223
Cheese	25	30	2	111
Beans, peas, and lentils (dried)	24	1	60	102
Beans (in pod)	5	—	15	23
Potato	2	—	15	19
Turnip	1	—	6	8
Onion	1	—	5	7
Apples	—	—	11	14
Bananas	1	—	14	19
Jam and marmalade	1	—	50	59
Sugar	—	—	98	114
Honey	—	—	81	95

* From "Food and How to Save it," by Dr. E. I. Spriggs.

are of great value in constructing a dietary because of their relative cheapness. They possess the drawback of being less readily and completely digested than the animal proteins. The cheapest source of animal protein is probably cheese, while separated milk also yields a cheap supply of proteins.

Although fats and carbohydrates can largely replace one another, it is not a matter of indifference which is taken, and the cheaper carbohydrates cannot be used entirely to replace fat. Different authorities give figures for the amount of protein considered as essential, varying from as little as 70 to as much as 130 grammes. The tendency in recent years has been rather to reduce the minimal figure. At the present time quantities which are fairly generally accepted for a man of average weight doing a moderate quantity of muscular work are 100 grammes of protein, 100 grammes of fat, and 500 grammes of carbohydrate, in the twenty-four hours.

These quantities of food will yield 410 calories from the protein, 930 from the fat and 2,050 from the carbohydrate, or 3,390 calories in all. This tale of calories (say 3,400) is about the number required for a man doing moderate muscular work; with only light work 3,000 calories may suffice, while heavy muscular work requires a diet yielding 5,000 calories or even more.

Professor Bayliss gives the war ration in the field for our armies in 1917 as protein 158 grammes,

fat 200 grammes, carbohydrate 514 grammes, with a total energy value of 4,600 calories.

These facts form part of the very important subject of dietetics, and from them it is evident that the relationship of food to health, excluding all considerations of unsoundness or harmful additions, is a very complex one. It involves the possibility of illness not only from a general chronic excess or insufficiency of food, but also from an excess or insufficiency of particular essential elements in the food.

Effects of insufficient food.—While the body can tolerate without much harm an insufficiency of food lasting for only comparatively short periods, prolonged and chronic inadequacy of food is highly injurious. Similarly, an ill-balanced diet, one for example containing an insufficiency of proteins, if persisted in may be almost equally harmful and is a condition more commonly met with. A person on such a diet may be well nourished, even fat, and still be starved, the essential tissue-forming proteins (the most costly part of food) being inadequately represented.

If the body is supplied with less food than is necessary for its nourishment the balance of the energy required to carry on its various functions must be obtained from the body itself. From what has been said above, it is clear that the amount of energy absolutely necessary can be much reduced by measures such as the restriction of muscular

work, or the diminution of heat loss by warmer clothing, or by living in a warmer atmosphere. As we all know, a person resting in bed with adequate clothing will expend much less energy and so need far less food than one up and about and doing considerable muscular work.

Diminished energy requirements may temporarily reduce the need, but if the food is further reduced the energy necessary is obtained at the expense of the tissues themselves. They are burnt up in the body, the less vital (such as the muscles) being affected more than those necessary to life, which are but little wasted. Such a condition of affairs, if continued, will of course result in death, but long before that stage is reached a condition of lowered resistance to disease is induced which makes those who are so subjected very liable to be attacked by bacterial diseases. The prevalence of typhus fever in Ireland following the potato famine is a well-known illustration, while the ravages of influenza in Germany in 1918 were said to be seriously heightened and the death-rate much increased by chronic underfeeding.

The disease which is especially liable to be contracted is *tuberculosis*. The germ of this disease, the tubercle bacillus, is so widespread that most persons get infected. It is the debilitated, from chronic underfeeding or an insanitary environment, in whom the infection becomes established and who principally fall victims. Pro-

bably no small part of the phenomenal decline in tuberculosis during the last half-century has been due to the cheapening of food (especially sugar) and the consequent better feeding of the population generally.

Modern research has established that the body can be maintained in health on far less protein than was at one time considered necessary, but if the proteins are reduced beyond the safety minimum (probably at least 80 grammes in the twenty-four hours) the body becomes insuffciently nourished and the resistance to infection lowered.

Figures from inquiries made in London, York, Glasgow and elsewhere before the War showed that a considerable percentage of the population was chronically underfed. This was partially due to improvidence and to lack of knowledge of scientific marketing, combined with ignorance of food values, but was in the main the result of wages insufficient to supply the food requirements of the family. While the economic question may be tackled, there is a real danger that it may not go hand in hand with persistent education of the people in food values and the proper utilisation of food. The economic necessities of the War have done something in this direction, but not nearly enough of a permanent character.

Effects of excessive food.—The effects of a chronic excess of food are less evident and defined. With young, active persons excess of food is

eliminated without harm owing to the greater tissue changes and other activities involved in vigorous exercise. When the amount of food is beyond what the body can deal with, some of the excess of the non-nitrogenous food may be deposited as fat, but the remainder has to be got rid of, either by excessive decomposition in the intestinal tract or in part through the kidneys. In the former the decomposition changes may cause indigestion and a general feeling of ill-health from defective elimination.

Any excessive strain on the kidneys arises chiefly from excess of the nitrogenous food, since proteins cannot be stored in the body, and the overplus must be eliminated mainly through these organs. In spite of considerable speculation and inquiry it is not possible with our present knowledge to say definitely to what extent such excessive work thrown upon the kidneys damages them, but it is a likely supposition that it does so.

Vitamines. — Great interest has been excited in scientific circles in recent years by the discovery of certain accessory substances in food which are of paramount importance, since they are essential to health. As already mentioned, they are generally called vitamines, and are present in most natural foods, but only in quite small amount, while their chemical nature is at present unknown. They are essential to nutrition since definite disease results when they are withheld. Careful scientific

experiments have shown that when animals are fed on a mixture of *pure* protein, starch and vegetable fats, they do not thrive, and indeed die if the experiment is prolonged sufficiently. From the point of view of nutritive substances the supply is ample, but vitamines are lacking, and when they are added to such a diet, for example by the addition of a quite small amount of fresh milk, satisfactory growth results. The vitamines are necessary to co-ordinate the materials and energy supplied by ordinary foods. It is sometimes advanced that mankind has had so long an experience in the selection of its food that conclusions based upon scientific and theoretical considerations are really of no practical value, and that man may safely be left to his own devices. While there is a good deal in this contention, the problems arising out of the discovery of vitamines show very conclusively that there is a limit to its application, and that when artificial methods of preparation of foods are introduced and widely adopted there is grave danger of ill-health resulting from food selection uncontrolled by scientific considerations. Examples of such artificially treated foods are tinned foods, milled wheat, rice and other cereals, and the substitution of made-up vegetable fats like margarine for butter. The two best known instances of diseases being so caused are beri-beri and scurvy.

Beri-beri is a disease chiefly met with abroad

(Japan, the Malay Peninsula, the Dutch Indies, etc.), and characterised by wasting and other more definitely nervous symptoms due to inflammation and degeneration of certain of the nerves. Individuals so affected almost invariably have been found to have lived on a diet which entirely or mainly consisted of "polished" rice, i.e. rice from which the husk had been removed. The number of cases of this disease increased markedly with the introduction of modern milling machinery. The classical figures of the Dutch physician Eijkmann dealing with prisoners in the jail of the Dutch East Indies, published in 1897, strikingly illustrate this relationship. In 37 prisons unpolished rice was employed, and only in one of these institutions did cases of beri-beri arise; in 13 prisons both polished and unpolished rice was used, and this disease developed in 6, while in 51 prisons where only polished rice was eaten, in 36 beri-beri occurred. The facts are even more striking when individuals are considered. Per 10,000 of the prison population, there was only one case amongst the eaters of unpolished rice compared with 416 on the dietary of the mixed rice, and 3,900 on polished rice alone. The essential difference between the two kinds of rice was that in the polished variety the germ (or embryo) and the very thin layer lying outside the husk-free seed were also removed.

On a diet of ordinary (unpolished) rice the disease does not occur, while, if not too advanced,

it can be cured by a diet containing the appropriate vitamine. The disease can be reproduced experimentally in birds by feeding them upon a diet of polished rice.

Scurvy is another deficiency disease, and is due to the consumption of food lacking in a particular vitamine over a considerable period of time. This vitamine is contained in a number of fresh foods, particularly lemons, oranges and fresh green vegetables, but is also present in smaller quantities in swedes, potatoes and other tubers, and in even smaller amounts in fresh meat and milk. It is absent in all dried and preserved foods. The destruction of the anti-scorbutic properties of food depends rather upon the time than upon the temperature employed. Prolonged heating, such as takes places during stewing, destroys the vitamine.

While peas, beans and lentils in the dried condition have no anti-scorbutic properties, if soaked in water and allowed to germinate for one or two days they develop the vitamine which can prevent scurvy.

These facts, some of which have only recently been established, explain the value which for many years has been attached to a fresh diet, and particularly to the administration of lemon juice as an anti-scorbutic remedy. It is an excellent illustration of a scientific explanation being forthcoming for measures introduced as the result of

careful observation and of proved reliability but for which the scientific reason was unknown. Deductions from observations, if accurate and controlled, are always of great value, even if the underlying explanation is wanting or given incorrectly.

Although these substances have not yet been isolated, we know that there are a number of vitamines or "accessory factors" in foods. Two at least are essential for nutrition, one of them associated with certain fats, while the other is soluble in water. Both must be present if nutrition is to progress in a satisfactory manner. It is also of interest to note that plants are dependent for normal growth on similar factors.

Experts are still not unanimous as to whether the boiling of milk damages it in any essential. The minority, who take the view that it does, consider that, amongst other points of objection, boiling destroys the vitamines which are present in fresh milk. While there are some facts showing that the vitamines in milk are diminished by boiling, the balance of evidence shows convincingly that it does not to any important extent affect the nutritive value of milk for infants. It is a question of a hypothetical drawback against the manifest dangers of bacterial infection from unboiled milk.

Rickets is a very widespread and prevalent disease which is closely associated with a faulty diet, but for which up to the present we cannot

ascribe any one definite cause. A theory widely accepted at one time was that it was due to a deficiency of fat in the food, but recent investigations have rather discredited this view, and the latest series of studies suggests that inadequate exercise and insufficient fresh air are more potent factors than questions of diet in causing this disease. On the other hand, there is a good deal of evidence that this disease is due not so much to a general deficiency of fat as to the absence from the diet of a sufficiency of the fat-soluble type of vitamine.

Vegetarianism. — Like many other popular expressions, this term will not bear a literal interpretation, and, as used in practice, a vegetarian means not a person who lives on vegetables, but one who avoids the use of animal flesh as an article of diet. A discussion of this cult on its moral ground that humanity forbids the slaughter of animals for food is outside the scope of this volume, but a further claim is made that physiologically such a diet is justifiable as healthier and better for the individual than one containing meat.

The facts already furnished show that it is possible for man to obtain all the nourishment he needs without any recourse to the flesh of animals. As regards carbohydrates, it is evident that in any case non-fleshy foods must be his main source of supply, while it is possible to obtain from

vegetable sources any fat which cannot be replaced by carbohydrates.

It has, however, been shown that man requires proteins in considerable quantity, and the crux of the physiological argument is whether he can obtain these better, or at least equally well, from vegetable sources. The tabular statement given on page 8 shows that, excluding eggs, milk, and cheese, all of which are of animal origin, he must either consume such vegetable foods in very large quantities, or utilise only certain varieties, such as beans, peas, and lentils, which require a good deal of digestion, and are apt to pall on the appetite when long continued. If a more varied vegetarian diet is selected, it is likely to be dangerously low in proteins, and those living upon it, while possibly well nourished, are deficient in energy.

The processes of digestion are considerably longer with a vegetarian diet, but given a temperament which can habituate itself to a rather monotonous diet and find ample leisure to make the best of it, a purely vegetarian diet may yield sufficient nourishment to maintain the body in full vigour. Most persons with heavy calls upon their energies have not time to be vegetarians, and flourish best upon a diet containing meat—i.e. one containing an abundant supply of readily digested protein.

Mr. Bumble, of immortal memory, had evi-

dently flickerings of physiological knowledge when he at once ascribed the unexpected ebullition of physical vigour and fearlessness on the part of little Oliver Twist not to madness but to *meat.*

"'Meat, ma'am, meat,' replied Bumble, with stern emphasis. 'You've over-fed him, ma'am. You've raised an artificial soul and spirit in him, ma'am, unbecoming a person of his condition: as the board will tell you. . . . If you had kept the boy on gruel, ma'am, this would never have happened.'"

Naturally poisonous foods.—There are a good many animals which produce poisonous secretions as part of their defence against other animals, or which utilise them as a means of killing their food. Well-known examples are the poisonous snakes, some fishes such as the sea weaver, scorpions, and a number of insects. They exert their action by injecting their poisons into the bodies of their victims, and such poisons are largely without effect when introduced by the mouth. These animals can be eaten without risk, and therefore cannot be included under the above heading as poisonous in themselves.

The number of animals whose flesh is definitely poisonous when eaten is small, and, apart from a few shell-fish which may be poisonous, they are all fishes.

By far the most important of these fishes belong to one family of tropical fish called the Tetro-

dontidæ. This family—the puffers, balloon fish, globe fish—includes a number of species of which the best known is the Japanese fugu. Many thousands of persons have been poisoned by eating this fish. In some cases the symptoms resemble those which are met with in ordinary attacks of food-poisoning (*see* p. 124), but in others they are much more rapid in their onset, with pain, collapse, and cramps, and closely resemble an acute attack of cholera. Death may occur in as short a time as twenty minutes. The poisonous symptoms have been shown to be due to a chemical body, somewhat like alkaloids such as strychnine or atropine, isolated from some plants.

Most observers have drawn attention to the fact that the degree to which the members of this group of fishes are poisonous varies greatly even with the same species of fish. This has been shown to be due to the fact that the poison is chiefly contained in the reproductive organs (the *roe*), and therefore their poisonous properties vary with the degree to which these organs are developed (season of year, etc.), and the extent to which these parts are eaten.

While all the most poisonous fishes are tropical, some common European fishes, such as the barbel, sturgeon, carp, and bream, are said to be harmful. They are not, however, poisonous to any marked extent, and then only at certain seasons of the year.

Food and the Public Health

That many flowering plants are poisonous is well known, and occasionally some of them, such as water hemlock for parsnips and celery, aconite for horse-radish, are eaten in mistake for edible foods. This does not often happen, and most cases of illness of this kind occur in children who have eaten poisonous berries.

Nearly all the cases of poisoning of vegetable nature are from poisonous fungi eaten in mistake for edible mushrooms. The number of poisonous mushrooms is large, but only a few are liable to be mistaken for the edible kinds. Nearly all the cases of poisoning have been due to two fungi, the fly fungus (*Amanita muscaria*) and the death-cup fungus (*Amanita phalloides*).

It is interesting to note that recent investigations have shown that the poisons in these two fungi are quite different. The fly fungus contains a very poisonous chemical body called *muscarine,* and it is to this substance, acting with some other body or bodies not yet isolated, that the very fatal effects are due. The death-cup fungus contains an extremely toxic body which is not easily destroyed by heat, and which has been isolated. The occurrence of this heat-resisting body explains why this mushroom remains intensely poisonous even after cooking. This substance (*a-toxin*, as its discoverer calls it) is one of the most powerful known poisons of plant origin.

While cases of poisoning from other kinds of

mushrooms have been recorded, the number is small compared with those of the two fungi mentioned.

Quite apart from the question of foods which are naturally poisonous or which have become infected with chemicals, animal parasites or bacteria, we very occasionally find that certain foods may cause ill-health in some individuals while eaten with impunity by the rest of the community. Shellfish, eggs, and nuts are types of such foods. The fault in these cases is clearly with the individual and not with the food, and is usually spoken of as a food idiosyncrasy of the particular person. It is only in quite recent years that the scientific causes of this condition began to be understood. While important to the individual, these cases are but few in the aggregate, and are probably due to a special condition which allows some of the unaltered proteins of the food to pass unchanged into the blood, where they act as foreign bodies and give rise to the symptoms. All the foods of this kind which specially disagree contain proteins.

CHAPTER II

Chemical Additions to Food

In one way or another harmful chemical bodies may gain access to food from a number of different sources. They can all, however, be grouped into three classes.

1. Introduced unintentionally in connection with processes of manufacture.

2. Added from the action of the food upon the retainers in which it is put upon the market.

3. Deliberately added to food to preserve its quality or enhance its appearance.

1. Chemicals introduced unintentionally in manufacture.— Foodstuffs are so diverse in origin, varied in nature, and complicated in their methods of preparation that there are considerable possibilities that in one way or another many chemical substances may be unintentionally introduced. In practice, however, not a large number of poisonous chemicals have been detected, the most important being salts of arsenic, tin, copper, and lead.

Arsenical compounds are widely diffused in nature, and quite minute traces are not uncommon in many foods and substances used for the pre-

paration of food. It was not until the extensive and widespread outbreak of arsenical poisoning in 1900 directed attention to the subject that the danger of arsenic in food was realised and adequately studied.

This outbreak so admirably illustrates the dangers of chemical food contamination from sources not immediately associated with food production that it is worth while considering it in some detail.

During the latter part of 1900 a very extensive outbreak of sickness, involving well over 6,000 persons, with more than 70 deaths, attributable to poisoning by arsenic, occurred in England and Wales. The very careful inquiries made showed that the outbreak was due to beer contaminated with arsenic. In every case this beer was supplied from breweries which made use of brewing sugars (i.e. glucose and invert sugar) supplied from a single source. These sugars are extensively used instead of, or as additions to, the malt sugar obtained from grain fermentation. As much as ½ to 9 grains of arsenic per pound were found in these different sugars. In their preparation sulphuric acid is used, and the arsenic was derived from the acid, which was found to be heavily contaminated with arsenic (from 1.4 to 2.6 per cent.).

It was found that the beer as consumed contained from ¼ to 1 grain of arsenic per gallon,

while in exceptional cases much larger amounts were detected. These are large quantities for this substance, the medicinal dose of arsenic being $\frac{1}{60}$ to $\frac{1}{12}$ grain expressed as the oxide.

A careful study by the special Royal Commission appointed, showed that minute quantities of arsenic in beer might also gain access from malting if the grain were exposed on the kiln to the products of combustion of fuel containing arsenical materials. An outbreak of arsenical poisoning at Halifax in 1902 was due to beer contaminated in this way.

Arsenic may gain access to various foods. Thus it has been found in sweets when glucose contaminated with arsenic was used instead of cane sugar. An extensive outbreak of 62 cases of arsenical poisoning occurred in Manchester in 1908 from sweets contaminated in this way.

Arsenic has been found in cheap confectionery derived from shellac used to coat the confectionery. It may be deposited on the surface of fruit treated with insecticides containing arsenic. Recently it has been found in a considerable number of samples of baking-powder substitute in this country. The substitute contained acid calcium phosphate instead of cream of tartar, and in this were found substantial amounts of arsenic. Here again the actual source of the arsenic was from sulphuric acid used to prepare the acid calcium phosphate.

The insidious ways in which arsenic may obtain

access to food will perhaps be clearer from the following diagram :

Materials for making sulphuric acid
containing arsenic

Sulphuric acid.

Glucose. — Acid calcium phosphate.

Sweets. — Beer. — Baking-powder substitute.

Flour.

Arsenic is so powerful a poison that no arsenic should be tolerated in food. The Royal Commission on the subject reported they "are not prepared to allow that it would be right to declare that any quantity of arsenic, however small, is admissible in beer or in any food."

Lead is another metal which is found in many foods and may be derived from very diverse sources. For example, some of the enamels used for glazing earthenware contain lead, and may give it up to the foods put into such vessels; tea is wrapped in lead foil, wine bottles are sometimes cleaned by shaking lead shot in them, soda-water siphons are fitted with valves containing lead, and cider may be heavily contaminated with lead from vessels used in the course of its manufacture.

In all these ways lead may gain access to food and be a cause of chronic poisoning, but few definite cases from these sources have been recorded except from contaminated cider. Cider, which contains a vegetable acid called malic acid, was at one time responsible for a number of cases of lead poisoning from being allowed to come in contact with lead vats during the process of manufacture. So prevalent was this form of lead poisoning in certain parts of Devonshire and adjacent areas that it was locally known as "Devonshire colic." This source of metallic poisoning has now been almost entirely done away with.

Tin, apart from tinned foods, which are discussed later on, does not occur to any material extent in foods.

Copper, in poisonous quantities, only very rarely occurs in foods, but outbreaks have been reported from food contaminated with copper derived from cooking utensils of this metal. Under rare circumstances copper is found in oysters, but the popular impression that all "green oysters" are of that colour because of the presence of copper is incorrect. It is doubtful if poisoning ever arises from this source.

2. **Chemicals introduced from the action of food upon the retainers.**—The amount of food now tinned is enormous. In the United States alone for the year 1909 it was valued at some £58,000,000. The foods tinned are very varied,

but are mainly meat foods, condensed milk, fish, shellfish, fruits, and vegetables.

Most of these canned foods are packed in tin-plate receptacles owing to the convenience of this material in handling, sealing off, and transport. The only metal of any importance which may gain access to the food in this way is tin.

The amount of tin found in such foods varies greatly, as it depends upon a number of factors of which the following are the most important:

(*a*) The nature of the food canned. This is mainly a question of acidity: the higher the acidity the larger the quantity of tin taken up. Vegetable foods, for example, have a considerable natural acidity.

(*b*) The period since canning. The longer the time the greater the amount of tin dissolved.

(*c*) The quality of the tin-plating. When this is thin the acids eat through to the steel or iron beneath, the two metals act electrolytically, and the amount of tin dissolved is increased.

(*d*) The solder used and the method of soldering. Tin may gain access and be dissolved from the solder used.

The quantity of tinned food consumed is very large, while the popular idea that harm may result from tin contained in it is widespread, so that considerable attention has been given to this question by the authorities responsible for the purity of food. The Food Inspection Department

of the Local Government Board, for example, has issued a valuable Report upon the subject.

Tin, like arsenic, is a poisonous substance, but with the differences that not only is it much less toxic but, unlike arsenic, is not cumulative in its action, or only very slightly so. By a cumulative poison is meant that the substance is deposited in the body and continues to exert its action over a period prolonged considerably beyond that of its ingestion. In this way quite minute doses, each by itself insufficient to produce symptoms, may exert a poisonous action through their cumulative effect. This applies to lead as well as to arsenic, but hardly at all to tin. This is one important reason why even very minute additions of arsenic to food must be regarded with great suspicion.

Any action that tin is likely to exert will be through its irritating action upon the lining of the stomach and intestine. To exert any such action tin salts would have to be present in considerable quantities in the food. The known facts show clearly that such irritant action may take place, but, to be exerted, at least one to two grains of the tin salts to the pound would have to be present. To produce these symptoms of irritant poisoning canned foods would have to contain much larger amounts of tin than occur in such foods as supplied for consumption in the ordinary way.

The expert who worked on this subject for the Local Government Board selected certain canned

foods between one and two years from the date of canning (an extreme limit for ordinary stock), choosing peaches, apricots and other fruit specially liable to act on tin. In these samples the quantity of tin present did not in any case exceed one grain to the pound of fruit, and, as the author of the Report states, "There seems no reason to believe that such large quantities of tin as two or three grains in the pound would in ordinary circumstances be present in any of the usual canned foods of commerce, provided that proper care had been taken to avoid contamination of the contents by solder."

Actual cases of reported tin poisoning from canned foods are very rare indeed, considering the quantity consumed, and when these are scientifically investigated scarcely any can be proved to be due to tin. Several investigators have in fact dosed themselves with considerable quantities of tin in food without any evidence of harm. The comparative harmlessness of tin in canned food is shown also by the vast practical experiment in which large sections of the community forming our armies have been fed on canned foods over long periods of time without any evidence of metallic poisoning resulting.

Summing up the matter, it may be said that, although considerable quantities of tin may be found in food, there is little evidence that harmful results have ensued, as the toxicity of this metal is

not high. There is very little danger, therefore, of poisoning with tin from canned foods.

In this connection, as illustrating the popular prejudice on the subject, it may be mentioned that a considerable quantity of the food sold to the public in glass receptacles is really tinned food which has been transferred before being put upon the market. The cost of the transfer is more than recouped by the greater attractiveness to the public of the food in glass retainers and the higher price obtained in consequence.

It might be supposed that in view of this popular prejudice against food in metal retainers more of it would be put up in glass receptacles. Against this is the increased primary cost of glass vessels, the loss from breakages, the greater weight and cost of freightage and the much greater difficulty of sterilising the food. It is much easier to sterilise meat (for example) in cans than in glass containers, so that the use of the latter necessitates the observance of greater care and cleanliness in their preparation. To obviate this, chemical preservatives are often added.

3. **Chemicals deliberately added.**—The problems which arise in connection with the addition of preservatives to food are of the utmost practical importance, but are very difficult of solution.

It is well known that foods are preserved by the use of chemicals to a very large extent. The food purist may maintain that they are not required,

and may demand that their use or addition be entirely prohibited. A little reflection, however, will at once show that such a simple and uncompromising attitude is an impossible one to take up in practice.

Owing to the perishable nature of foods and the fact that at certain times some are plentiful while at others difficult to get or unobtainable, man throughout his historical existence has resorted to forms of food preservation. In addition, he has found that preservation, in some of its forms, materially alters the taste and quality of the food, and in this way he has obtained new and frequently more palatable types of food. Food preservation not only enables the food of seasons of plenty to be kept unimpaired against the times of scarcity, but it allows rapidly perishable articles to be transported in good condition from regions of origin to places of consumption.

The earlier methods of preservation practised were mainly not of a chemical nature, the commonest being drying or smoking. The next development consisted in using such simple and well-known chemical substances as common salt, sugar, and vinegar, and all these methods are still employed on an enormous scale.

To these older processes sanctioned by custom and used for centuries without demonstrable harm no objection on the score of injury to health has been raised, nor can objection be advanced to such

simple non-chemical methods as preservation by heat and refrigeration. It is to the addition of certain more recently discovered chemical substances, specially added as preservatives to prevent bacterial decomposition, that so great objection has been taken, and which is so much a question of controversy. The best-known of these preservatives are boric acid and its compounds (including borax), salicylic acid and its salts, sulphites, formaldehyde, and benzoic acid and its salts.

There is no dispute that all these newer substances added as preservatives are harmful to man in large doses, but those who justify their addition do so on the ground that their harmfulness in the small quantities in which they are added to foods under actual practical conditions has never been proved.

The opponents of their addition to foods are able to adduce a number of reasons for objecting to their use, of which the following are the most important :—

(*a*) That there *is* evidence that the preservative added is itself harmful to man in the amounts found or which may be present.

(*b*) That these preservatives are added to check bacterial decomposition, or in popular parlance to prevent the food going bad. Their addition allows such food to be collected, prepared or stored under conditions which are distinctly prejudicial to health, such methods being practicable commer-

cially only because the added preservative prevents the food decomposing, which it otherwise would do under these unhygienic conditions.

(*c*) That even if it be granted that these preservatives, in the amounts found, may not be harmful to ordinary healthy people, they are likely to be so to certain sections of the community, such as the delicate, the diseased, or the young. There is no way of shielding such susceptible persons from being poisoned with these chemical preservatives, since the law does not require either their presence or their amount to be disclosed.

(*d*) That the fact that present knowledge may be insufficient to prove their harmfulness does not enable us to say that if they are taken in food over prolonged periods they may not be a cause of ill-health. In other words, it is a fair line of argument to take that the addition to food of substances which are known poisons in large doses may exert a definite, if unknown, deleterious action upon the body when taken in small doses over long periods, and that the public should not be subjected to this risk, even if problematical, without their knowledge or consent.

Of the harmfulness of these substances in large doses there is no doubt, and since their addition is often in the hands of people quite ignorant of the niceties of chemical dosage it frequently occurs that very much larger quantities are added than are necessary. For example, the writer once

found the enormous amount of 96 grains of boric acid per pound in brawn, and the brawn-maker's excuse was that as it was rather hot weather he took a small handful and mixed it in. He evidently thought it could be used like common salt.

A great deal of scientific evidence has been brought forward both as to the harmfulness and as to the harmlessness of individual chemical preservatives in quite small doses, much of it conflicting, while a good deal is unequal in value.

The present legal, scientific, and administrative positions are alike unsatisfactory. Except for preserved cream, in which small declared amounts of boric acid are permitted, and for milk, to which their addition is prohibited, there are no legal enactments directly permitting or penalising the addition of chemicals to food. This presses very hardly upon all sections of the community. The general public are, all unwittingly, obliged to consume a considerable proportion of their food mixed with chemicals which may be harmful, and as they do not know if they are there or not they cannot decline to buy such food.

The food manufacturer and the food seller do not know if they may or may not add these substances, and this uncertainty may be injurious to their business interests, since trade rivals may lack their scruples, and by a plentiful use of preservatives may avoid loss from damaged goods, or the expense (much more costly than the addition

of preservatives) of strict cleanliness in manufacture or storage. Also there is great inequality in different districts, some local authorities being very lax, others dealing actively with preservatives under the rather roundabout existing laws.

Local authorities are in an even more difficult position, since the existing legal machinery for dealing with preservatives is very unsatisfactory, and each case may have to be fought out on scientific grounds in which proof has to be adduced of the harmfulness of the preservative present and in the amount found. This is a wasteful business, and likely to be very expensive to both parties.

That this is the case will be evident from the two main legal sections under which prosecutions have to be taken. They are Sections III. and VI. of the Food and Drugs Act, 1875. Section III. provides that no article of food intended for sale shall be mixed, stained or coloured, or powdered, so as to render it injurious to health. Section VI., that no person shall sell to the prejudice of the purchaser any article of food or any drug which is not of the nature, substance and quality demanded by such purchaser.

Under these sections it will be noted that it is not expressly declared that no preservatives may be added, but the prosecuting authority has either to prove injury to health or that the added substance is to the prejudice of the purchaser.

It is important to realise that the addition of small and defined amounts of certain preservatives to particular foods may be an advantage to the community by enabling such foods to be preserved and sold at cheap rates, and this advantage may outweigh any possible harmful action. If this be granted, it is very necessary that the whole question of the addition of chemical preservatives to food should be placed upon a proper scientific and legal footing.

The new Ministry of Health, with its advisory bodies of experts, should find it perfectly feasible to enact suitable regulations setting out the preservatives which may be used, with the maximum amounts for the different foods, requiring that if these permitted substances are added the fact must be adequately set out on the label, and prohibiting the sale of preservatives under fancy names. The addition of all preservatives outside this permitted schedule should be completely prohibited. It is quite useless to say that certain specified preservatives should be prohibited, and leave the matter there, since the trade chemist can always be relied upon to find fresh ones. The attitude to be adopted is that of prohibiting all preservatives except those scheduled as permitted under defined conditions.

Colouring matters.—Allied to the question of preservatives is that of colouring matters. Several generations ago a good many foods were adulter-

ated with colouring matters distinctly harmful in character. Examples are various salts of iron, red lead and chromate of lead, sulphate of mercury, coloured salts of arsenic, etc. The use of such deleterious substances has practically ceased, partly owing to a recognition of their harmfulness, but also because the introduction of aniline dyes rendered their use unnecessary. Practically all those added at the present day (apart from salts of copper) are vegetable or aniline dyes, which, so far as is known, are harmless.

Annatto is the most extensively used of the vegetable dyes, and is still the principal substance used to dye butter, milk and dairy products generally. It is also added to margarine. Turmeric is another vegetable stain sometimes employed. There is no evidence that either of them is harmful. A very wide range of aniline dyes is used, and very many foods are so coloured.

While these vegetable and aniline dyes are harmless, their addition is a waste of material, while in certain cases they mask the quality of the food and may render saleable food which otherwise would be rejected as of inferior quality and unfit for food.

The only one of these dyes which may be distinctly harmful is salts of copper, added to peas and other vegetables to give them a good colour. There is still some controversy as to whether this addition has given rise to ill-health, but the latest

expert information, as contained in the special Report issued by the U.S.A. Board of Agriculture, is to the effect that it may do so even in the small amounts which may be used. Copper salts may also have the effect of concealing inferiority, inasmuch as the bright green colour imparted to the vegetables simulates a state of freshness they may not have possessed before treatment.

CHAPTER III

Bacterial Diseases Disseminated through Foods

MOST of the diseases conveyed by food are due to the activities of bacteria. To obtain clear ideas as to how these diseases are caused, it is necessary to understand something of the essential nature of bacterial infections.

Infection is not simply a matter of the presence of a particular harmful germ; it is a *process*, and one of considerable complexity. To understand it involves consideration of the properties of the invading organism and of the powers of resistance of the individual attacked, while it is materially affected by such important points as the path of infection and the dose of the bacteria introduced.

Bacteria.—Bacteria are extremely minute living forms of vegetable life of very simple structure. The vast majority are incapable of inducing disease in man or animals, and live a harmless vegetable existence—the so-called saprophytic bacteria. The ability of bacteria to cause disease depends upon the nature of the chemical products they elaborate. Like all living things, they pro-

duce something as a necessary accompaniment of their growth. These products may be simple in nature, such as acids, gaseous chemical bodies, or pigment, or more complex, though still harmless. The minority produce bodies of considerable toxicity to animal life, and it is these which constitute the group of pathogenic or harmful bacteria.

The requirements for growth of the ordinary saprophytic varieties are comparatively simple—a sufficiency of moisture, a temperature which often can vary within wide limits, and a food supply which contains small quantities of organic matter. Even the latter is not necessary for all varieties. Conditions such as these are almost universally present, so that bacteria are extremely widely distributed in nature.

Pathogenic bacteria.—The varieties harmful to man and animals are more restricted in their requirements. Some have become so accustomed to a parasitic life within the animal body that they cannot flourish outside it, except under the highly selected and artificial conditions provided by the bacteriologist in his laboratory. If they do get into the outer world they may survive for a short period—often to be measured only in hours or less—and then die. Examples of this type are the bacteria of influenza and cerebro-spinal fever, and their highly specialised requirements explain why such diseases are never spread by food, since if they did gain access (for example, by a sufferer

sneezing over meat or milk) they would so quickly die that infection is but a remote possibility. Others of the pathogenic bacteria are more tolerant in their requirements, and while they flourish best within the animal body, they can live outside it for considerable periods, and often markedly increase in numbers under saprophytic conditions.

Harmful organisms of this type, which includes the typhoid bacillus (the cause of typhoid fever), the organism of cholera, and *Bacillus enteritidis* (a common cause of food-poisoning outbreaks) are a much greater menace to health, since they can also be distributed by these indirect methods.

Obviously much will depend upon the kind of material into which such bacteria are introduced when shed into the outer world. If they gain access to a foodstuff upon which they can not only survive but multiply, they are more likely to cause widespread outbreaks than when introduced into a medium such as water, in which they merely survive for a comparatively short period.

Pure saprophytes introduced into the animal body die out more or less rapidly. While in their extremes there is a sharp difference between the pathogenic and the true saprophytic types, there are all gradations between, and there are pathogenic varieties which can adapt themselves to and persist in a saprophytic life, and saprophytes which can accustom themselves to living indefinitely in the animal body.

We have also to recognise that bacteria breed true, like producing like, and while no doubt in the remote past the pathogenic types have originated from the saprophytes, there is no evidence to warrant the assumption that any particular harmful strain we may encounter has bred from other than the same pathogenic stock.

Even, however, with the same strain, exposed to different conditions, considerable variations as regards the toxicity of its products, or degree of virulence, as it is called scientifically, are met with, and this is an important factor in determining whether infection takes place.

An important feature of bacteria is their rate of growth. The ordinary method of increase is by a process of simple fission of the parent cell into two, and as this can occur under favourable circumstances after as short a period as half an hour with many varieties, their rate of increase is enormous. A simple calculation will show that theoretically, if this rate of increase could be maintained, a single bacterium at the end of twelve hours would produce 16,800,000 descendants. Under actual conditions this fabulous rate of increase is sharply checked by the fact that the products of its own growth are harmful to the organism and in time check its multiplication.

A further point of importance is the resistant powers of bacteria to adverse conditions. Certain varieties produce spores, which are very much

more resistant than the parent cell. All the spore-bearing types, of which the bacilli of tetanus and anthrax are good examples, are highly resistant. A few organisms possess added powers of resistance owing to the nature of their outer walls or envelopes, and of these the bacillus which causes tuberculosis is the most important. Its fatty envelope enables it to withstand dryness and heat considerably better than the ordinary non-sporing types.

In general the conditions most unfavourable to bacteria are light, especially sunlight, dryness, and temperatures above 45° C.

Susceptibility to bacterial invasion.—Equally involved in the process of disease production are a number of factors which concern the animal body (man or animal) invaded. As is well known, all persons are not equally susceptible to disease. Some possess a natural resistance; in others resistance has to be acquired. For example, certain diseases in animals, such as swine fever or dog distemper, are unknown in man, while diseases like typhoid fever or cholera are not met with in the lower animals. Man or animals respectively are unsusceptible to these diseases, and such a condition is known as natural immunity.

It is also well known that after an attack of certain diseases (smallpox for example), persons, although they may be subsequently exposed to infection, never, or very rarely, contract that

disease again. In other words they have acquired immunity against that disease. An immunity of this kind is special, or specific, as it is usually called; that is, it protects only against a particular disease. Such acquired immunity can be produced by artificial methods, an excellent example being the immunity against typhoid fever obtained by the inoculation of our soldiers with typhoid vaccine.

The causes of immunity, natural and acquired, are complex and cannot be discussed here,* but their existence shows how very complicated are the problems of bacterial disease. We can best represent the matter as a battle in which the prospects of success of the invading organisms are affected on the one hand by their numbers, their virulence and the toxicity of the chemical products of their growth, and on the other by the powers of resistance possessed by the individual invaded, which may be only the natural defensive mechanism possessed by all animals (including man), or may be this mechanism fortified by the effects of a previous attack of the same disease, or by an artificially induced immunity. If the invading bacteria succeed in their attack they establish themselves, infection results, and the special disease which they cause develops. If the powers of resistance are sufficient nothing happens; the invader is repelled.

See Chapter IX. in "The Story of English Public Health," by Sir Malcolm Morris. 1919.

Bacterial Infection

Dosage of infection.—With this conception clearly established, the great importance of questions of dosage, paths of infection and natural resistance take on their true significance. It is obvious that if the attacking organisms are few in number they are likely to be killed by the defensive powers opposed to them before they can establish themselves, whereas if they are introduced upon such substances as meat or in milk, in which they can grow, they may have multiplied sufficiently to enable a certain proportion of them to survive the battle and entrench themselves.

Path of infection.—Again, the path of infection is important. Introduced by the mouth, the bacteria cannot, as a rule, establish themselves until they have travelled along into the lower part of the intestine, whence they are absorbed into the blood stream. To get so far they have to run the gauntlet of the digestive juices—salivary, gastric and pancreatic—all of which are inimical, in greater or less degree, to bacteria. Introduced in small numbers by the mouth, their likelihood of survival may be small, but their chances are directly increased in proportion to the number of bacteria so introduced, qualified by the powers of resistance of the particular strain. In illustration of this last point it may be said that the more resistant tubercle bacillus would have a greater chance of survival than an equal number of the less resistant typhoid bacillus.

The same bacilli introduced under the skin or by way of the air passages would be much more likely to escape the destructive influences lying in wait for them and so cause infection.

The vehicle of infection of the bacteria may play a part in another direction, as the food in some cases helps to protect the bacilli until they can establish themselves, either mechanically by providing a protecting medium, or chemically by neutralising or rendering less harmful the digestive juices.

A further aspect of the subject remains to be considered, i.e. the precise ways by which the bacteria capable of setting up human disease are conveyed through food. When the food is derived from an animal affected with the same disease (for example, tuberculosis) nothing further has to be explained, since the source of the pathogenic bacteria is clear. When, however, the food is of healthy origin, or not derived from animals at all, it is obvious that we have to ascertain how such food comes to be contaminated with these harmful bacteria.

Carriers of infection.—Of all such sources, the most important is man himself. In a case of infectious disease due to bacteria, if recovery takes place there occurs during its course a gradual mastery by the defensive powers of the body over the offensive properties of the invader, and recovery is marked by a reduction to impotence for that

individual of the powers for evil of the invading organism. In the majority of cases the bacteria are killed out, but in a minority they persist, sometimes for long periods. They cannot injure the person in whom they persist, since the defensive mechanism (immunity) is sufficiently developed to prevent it, but they have lost none of their virulence for other persons. If the sites where they survive communicate with the exterior, for example, if they persist in the nose, throat or intestinal canal, the excretions from these organs will contain the bacteria, often in large numbers, and as they can infect other persons they constitute a grave menace and source of infection. Such carrier cases are particularly prevalent in typhoid fever and diphtheria, but they occur with a number of other bacterial diseases. The bacilli may persist in this actively virulent condition, unsuspected by the individual, for periods which may be measured by months, weeks, or even years. For example, in diphtheria it is found that in 30 per cent. of the cases the bacillus disappears in about three weeks from the onset, in 40 per cent. in four weeks, in nearly 70 per cent. in five weeks, and in about 80 per cent. in seven weeks, while in the remaining 20 per cent. it may persist for many months. In typhoid fever the bacilli readily survive for years in a proportion of cases.

There is another group of carrier cases which arises in a different way. Some individuals, more

fortunate than most of us, do not need when infected to battle first with the invading germ and then after desperate strife to develop an acquired immunity, but possess in themselves a sufficiency of these immunity products to prevent the development of the disease. The germ invades but does not infect, yet may remain in the body. In this case we get what is called a passive carrier. In diphtheria such passive carriers are very numerous, but they are infrequent for typhoid fever.

Intermediate between the two are many cases in which the immunity powers are so considerable that while infection occurs its manifestations (symptoms) are so slight and evanescent that they frequently escape notice. In a proportion of these slight unrecognised cases the bacilli persist, and while scientifically they really belong to the first group of carriers, they appear to belong to the second.

These germ carriers are particularly dangerous when they are brought into contact with food, and in this way they have caused a large number of outbreaks, especially of typhoid fever.

The career of the famous "Typhoid Mary" is a very good example. This woman was a cook, and was responsible for no fewer than twenty-six cases in seven different families. The final outbreak, which led to the recognition of her baneful influence, was in 1907, when two cases of typhoid fever occurred in the family in whose service she

was, two months after her arrival. Gaps in her history could not be traced, but it was established that the following cases had occurred in places where she had worked as a cook, viz. one case in 1901, one case in another family in 1901, nine cases in 1902 in another family, four in 1904 in a different family, six in one family in the summer of 1906, and one in yet another family in the autumn of the same year.

Nothing is clearer, from a study of different outbreaks, than the fact that all carriers must be kept from handling food. Their danger to the community is in direct proportion to their ability to infect food, and is multiplied greatly if they are of careless and dirty habits.

Far too little care is taken to exercise supervision over all persons who handle food. There is some legislative provision governing *places* where food is prepared, but none or practically none of any importance requiring supervision over *persons,* by far the more important of the two. The Department of Health of New York City made a start in such work by inaugurating, in 1915, detailed medical and pathological examinations of the cooks and waiters in a number of the hotels and restaurants of the city. Ten chronic typhoid bacillus carriers, and a considerable number of persons infective from syphilis, tuberculosis, etc., were detected.

While emphasis has been laid upon carrier

cases, it must not be lost sight of that in many instances food is infected through definite cases of infectious disease, including unrecognised cases, the patients having handled the food while still infectious. In some of these cases the path of infection is indirect, through intermediaries such as clothing or infected water. Examples are given in the following chapters. In a number of the cases the actual channel of infection cannot be traced. No doubt in many such instances the bacilli are conveyed by flies or in dust.

Flies and food contamination.—Many of the blood-sucking flies directly carry infection from case to case, but the ordinary flies of this country are non-blood-sucking insects and convey infection indirectly.

There are many varieties of these flies, but their habits are rather similar, and all may be indirect carriers of infection. The following particulars apply more especially to *Musca domestica*, the common house-fly. It breeds mainly in horse manure, other forms of excreta, and in refuse of all sorts. In houses it is attracted by and favours food of all kinds, and may be found in very large numbers on such food. Structurally it is peculiarly well adapted to carry bacteria and other matters, and when examined its hairy limbs and body are found to be crowded with bacteria, which can be readily brushed off on to any food or other surface it walks over. In addition it feeds on excretal

Yard of refuse destructor. Flies caught in an adjacent office carried some five hundred million bacteria each.

Flies from this shop, situated in a congested area of a large city, were heavily laden with bacteria.

(By courtesy of Dr. Hope.)

PLATE II.

matters, and so takes vast numbers of bacteria into its digestive canal, where they survive for some time and are distributed on to food from its excreta and vomit—for it is a constant habit of flies to vomit. It forms, therefore, a connecting link between filth materials and food, acting as a passive carrier of the material from the former to the latter. (Plate II.)

The bacteriologist has not only been able to show that large number of bacteria are entangled in the hairs of the body and limbs of flies, and are contained in their excretions and vomit, but has experimentally demonstrated that flies can be infected readily with harmful bacteria, such as the bacilli of typhoid fever or tuberculosis, if fed on contaminated material containing these organisms, and can then carry such bacteria to food and deposit them upon it.

In only a few instances has it been possible actually to isolate such harmful bacteria from ordinary flies, even in epidemic times, but this is due to the great difficulty of the isolation and the small proportion of flies likely to be infected at the time of the examination.

In many outbreaks of dysentery, typhoid fever, cholera and other filth-borne disease the close association of the cases with abundance of flies and heavy food contamination from that source has been very striking.

There is therefore strong justification for

accepting flies as important carriers of the infecting agent in this group of diseases, and for taking steps to prevent infection by their means. Such measures run along three lines—war on the adult fly (the least successful), prevention of the breeding of flies by adequately dealing with all fly-breeding material (house refuse, horse manure, human excretions, etc.) in such a way that flies cannot get at it, and protection of food by providing and using fly-proof coverings.

Dust and food contamination.—Another vehicle of infection is dust. This may be mechanically harmful from solid particles contained in it, but its properties as a conveyer of infection will depend upon the bacteria in it. The number of micro-organisms present in dust will vary with its source. Ordinary town dust contains on an average about 40,000,000 organisms per gramme (i.e. more than one hundred millions in each tea-spoonful). While, fortunately, the majority are of harmless types, a certain number of harmful bacteria may be present. A good many of the pathogenic bacteria will survive in dry dust for some time; they then gradually die. Some, such as the tubercle bacillus, or sporing forms like the bacillus of anthrax, will live for months; for others, such as the organisms of typhoid fever, dysentery or diphtheria, their life is spanned by a few weeks; while others, like the organisms of influenza and cerebro-spinal meningitis, measure their life in

hours. If such infective dust is blown over food it may infect it and spread the disease, although dust is probably not a frequent cause of infection compared with other methods of spread.

It is obvious to even the most superficial observer that there is much gross neglect in this country to protect food from flies and from dust, and no doubt a material amount of untraced infection results from these methods of conveying disease organisms to milk, meat and other kinds of food.

It will be convenient to discuss here some general methods of food preparation and preservation, since these really depend, in their scientific aspects, upon the properties of bacteria. The form of preparation which will first be considered is the cooking of food.

The cook as sanitary officer.—It is interesting to speculate upon the stages which marked the progress of prehistoric man towards higher standards of sanitation. In spite of some evils which have accompanied them, the introduction of methods of preserving food is undoubtedly a landmark of progress. Another, unassociated with any corresponding defects, is the introduction of the cooking of food. No doubt originally instituted to increase its digestibility and palatability, it also ranks as one of the most important of sanitary measures. It is obvious that all the foods consumed raw or imperfectly cooked—milk,

oysters, etc.—are much more likely to convey bacterial or parasitic diseases than cooked foods. The cook is an invaluable sanitary officer.

The amount of protection from such diseases which is obtained by cooking is much greater than is generally realised. For example, diseases spread by milk are far commoner in this country of raw-milk drinkers than on the Continent, where milk for the most part is boiled, while certain bacterial and parasitic diseases are decidely more prevalent in parts of Germany where raw or but lightly cooked meat is frequently consumed than in England.

Almost all the bacteria which can convey infection through food are easily destroyed by heat, a temperature of 60° C. (140° Fahr.) being fatal for all except the sporing forms and a few more resistant types, such as the tubercle bacillus, which may require a temperature a few degrees higher to destroy them.

Animal parasites are also killed at fairly low temperatures, since tapeworm larvæ die at 52° C., and encysted trichinæ (*see* Chapter VI.) at about 65° C.

There is so much dirty handling of milk, meat, prepared meat foods and foodstuffs generally, and the risks of infection from different sources are so considerable that everyone acquainted with things as they are and not as they ought to be acquires a violent prejudice in favour of well-cooked food.

At the same time it is essential to realise that the temperatures named must reach the bacterium or parasite to destroy it, and the temperature on the surface of the food may be very different from that of the interior. Meat, for example, is a poor conductor of heat, and the temperature reached at the centre of a joint is frequently far lower than the inexperienced would imagine. With a large piece of meat the temperature of the centre may not be higher than 70° C., or even 60° C., although apparently well cooked. With large hams (10 lb.) placed in water which is then heated, the water may boil vigorously while the interior of the ham may be under 40° C., even after half an hour's boiling. Heat takes a long time to penetrate to the interior of meat, and as Petri showed, with large pieces, even after three and a half hours' cooking, the temperature of the interior may be only 84° C. or less.

The same thing has been shown with meat pies. In the Derby food poisoning outbreak from infected meat pies it was proved that the temperature of the centre of a pie, having all the external appearances of being well baked, may not exceed 47° C. A batch of pies prepared in a hurry might be so cooked that bacteria might continue to grow in their centre during the greater part of their stay in the oven.

The presence of typhoid bacilli in apparently well cooked spaghetti has been demonstrated, and

such food, *after cooking,* served at a public dinner, caused an outbreak of 93 cases of typhoid fever.

The different methods of food preservation which have been introduced, and which are now so considerable a feature of our economic life, have as their primary object the prevention of the development of bacteria, so that the food may be kept for long periods without deterioration.

The addition of chemicals for this purpose has been dealt with in Chapter II. The use of cold, heat, drying, etc., may be conveniently considered here, as they all depend on their effect upon bacteria under these conditions.

Cold storage.—Bacteria, for the most part, are not readily killed by the application of cold, even when the temperatures used are a long way below the freezing-point of water. On the other hand, they do not multiply at these low temperatures, although there are a few harmless kinds which continue to grow slowly. The harmful bacteria, while not killed at once, gradually diminish, and after a shorter or longer period die out.

While, therefore, *prolonged* cold storage may be looked upon as an agency for eliminating or at least reducing the numbers of harmful bacteria, it is both safer and more scientifically accurate to regard it as a measure for keeping food in much the same condition, as regards the number of bacteria in it, as when instituted. This point is important, since it implies the need for cleanliness

and care in the preparation of the food before refrigeration.

The efficiency of cold storage depends upon the temperature maintained, the time of storage, and the nature of the food refrigerated. The temperatures reached may range from several degrees below freezing to a few above it; storage may last for periods measured in days or extending to months; some foods can be kept refrigerated without deterioration much better than others.

The most important food preserved by cold is meat, and this is done in two ways, i.e. by storage above freezing-point (chilled meat) and by storage at temperatures such as $-4°$ C. to $-10°$ C. (frozen meat). When meat is to be chilled it is placed in a cold chamber about 2° above freezing and comparatively slowly reduced to this temperature, the process taking about two days. It is then stored at a temperature of 1°-2° above 0° C. Under these conditions certain changes continue, due to enzymes present and slow bacterial action. These are of the nature of ripening, and are said to improve the flavour of the meat if not carried too far.

With frozen meat the carcasses are rapidly chilled at a temperature of about $-20°$ C., when the meat becomes frozen solid. It is then kept at a temperature at least 4° below freezing-point (Centigrade). Frozen meat requires great care in the subsequent thawing, as only if this is done slowly

does an approximation to the original condition take place. On the other hand, if the warming process is prolonged there is more opportunity for bacterial decomposition, and the diffusion currents which are set up in the warming may carry such bacteria in towards the interior of the mass. Such meat, when thawed, is softer and moister than in the fresh condition, and both chilled and frozen meat deteriorate more rapidly than the same food when fresh.

Fish and poultry are also preserved by cold to a large extent, both being subject to rapid decomposition. They are stored frozen and not chilled, and it is important to get them into the frozen condition without delay. Both kinds of food deteriorate rapidly after being thawed.

Eggs are preserved by cold storage, and this practice is increasing, so that this branch of food preservation is now of considerable importance. Great care is necessary to keep both the temperature constant (usually at, or just above, the freezing-point) and the percentage of moisture in the air suitable. It is very necessary that the eggs should be fresh and in good condition before being frozen, and bacteriological examinations show that there is a direct relationship between this factor and the number of bacteria present.

Butter can be preserved by refrigeration (chilling) for long periods, and as a rule there is no increase in the number of bacteria, nor do changes in

the chemical composition result, apart from a slow increase in acidity which is unimportant.

Other foods are preserved by cold storage, but the above are the most important.

Summing up the matter, it may be said that from the hygienic point of view the utilisation of cold is by far the best method available for the preservation of food. This method has the great advantage that it adds nothing and removes nothing from the food as regards taste, palatability, nutritive qualities or digestibility. As mentioned, its chief drawback is that meat and certain other foods, when removed from cold storage, deteriorate more rapidly than quite fresh food.

Drying of foods.—In preservation by drying, the heat of the sun or artificial heat is used, the aim being to reduce the water in the food below the minimum required for the multiplication of bacteria. As already explained, a certain degree of moisture is necessary for the growth of bacteria, and if the water is reduced below this amount the food ceases to be a nutrient material, and bacteria which may gain access will not grow. Such dried foods include meat and meat products, vegetables and fruits, and bodies composed mainly of carbohydrates. Biltong and pemmican are examples of dried meat; many fruits and vegetables are now preserved and sold in a dried condition; while biscuits and macaroni are dried foods mainly carbohydrate in nature.

For easily injured food the heat can be reduced and a comparatively low temperature employed by drying in a partial vacuum. The ordinary dried milk of commerce is largely prepared in this way.

Preservation by smoking is allied to drying, but in addition to the abstraction of water, preservation is also in part assured by the absorption of certain chemical bodies, antiseptic in nature, such as creosote, from the smoke. Fish and some kinds of meat are frequently preserved in this way.

Preservation by such well-known methods as the addition of sugar and salt is partially due to the chemical action of these substances preventing the growth of bacteria and partly to their withdrawing water from the food itself.

Canning. — The preservation of food of all kinds in hermetically sealed receptacles (metal or glass) has attained such considerable commercial importance and such food now constitutes so large a proportion of that consumed by the community that it merits some detailed consideration.

The preservation of food in this way dates from about 1810, but its extensive development has only taken place during the last two or three decades. The magnitude of the industry will be realised from the following figures, dealing only with the United States. In the year 1917 the amounts canned were—vegetables 58,738,330 cases, fish 14,456,180 cases, fruit 15,241,850 cases. The average case holds two

dozen cans. In addition, vast quantities of meat and milk are canned, the figures for 1909, in the United States alone, being 121,376,000 lb. of meat and 494,796,000 lb. of condensed milk.

The principles of preservation are much the same for all canned foods, but the details vary with each kind, while different methods are sometimes employed for the same foodstuff. The object aimed at is to subject the substance canned to a degree of heat which will destroy any contained bacteria without damaging the appearance or nutritive quality of the food. The heating is done either after the food has been sealed up in the containers or after partial sealing, when further contamination can be prevented.

Canned meat will serve as an illustration of the methods which are employed. As practised under the best conditions, the meat is obtained from selected lean (excess of fat being a great disadvantage) animals killed under carefully supervised sanitary conditions. The parts of the animals suitable are removed and cured in a pickle consisting of salt, nitre and water. After curing, the meat is forked out and transferred to a separate room where it is cooked in large vats. It is then trimmed, bone, gristle, etc., removed, cut up into pieces of suitable size, and pressed into the cans by means of special stuffing machines. The cans are next placed in a vacuum sealing machine which, when full, is closed and the air exhausted from the interior and

from the cans. When a sufficient vacuum has been obtained the cans are soldered down in the exhaust receptacle. After they have been sealed the machine is opened and the cans removed. They are then placed in retorts and "processed," i.e. heated to a temperature well above that of boiling water and for a definite period. The exact temperature and time vary in different factories, and also with the size of the tin. The subsequent processes consist of inspection to detect leaks, washing the cans to remove fat, painting and labelling.

Fish, such as sardines, herrings and salmon, are canned by somewhat similar methods, but considerable variations are met with in different canning establishments. In some the temperature of boiling water only is relied upon, and there is no processing at a high temperature. Other marine products extensively canned are oysters, lobsters and crabs.

Fruits are the easiest articles to can, as subjecting them to the temperature of boiling water for a short time is usually sufficient to ensure sterilisation. There is, however, with acid fruits, as compared with other canned articles, much greater risk of tin being dissolved, and frequently the inside of the tin is coated with a lacquer to prevent the acid from acting upon it.

Vegetables require a good deal more cooking than fruit, both a longer time and a higher tempera-

ture being employed. As a rule the tins are exhausted before processing, and in nearly all cases a preliminary blanching in hot water is given.

Condensed milk is separately considered in Chapter V.

In domestic preservation, chiefly employed for vegetables and fruits, the sterilisation is generally done in the jars after they are partially sealed, the temperature of boiling water (100° C.) only being employed. If this is done on three successive days it may be very efficient, thus following the procedure employed in bacteriological laboratories, but this is impracticable when the canning done is extensive, and a single sterilisation is usually relied upon.

A certain proportion of canned foods go bad in the receptacles from the development of bacteria. There are two common sources of spoliation. One is due to inadequate sterilisation, bacteria remaining alive; the other is due to bacteria gaining access from outside by means of minute leaks in the tins through the seams, solder hole, etc. The former chiefly occurs with foods canned in the home, the latter is the main source of infection with commercially prepared material.

Just as with ordinary fresh foods, care and cleanliness in preparation and the employment of foods which are in a fresh condition and free from disease are primary essentials. It is probably easier to mask these defects in canned than in fresh

food. There is no scientific basis for considering properly prepared canned foods as either less nutritive or more liable to be harmful than the corresponding fresh foods, provided they do not form too large a proportion of the diet. The vitamines have been destroyed and these must be supplied from other sources. Canned foods have the material advantage that their cooking protects them against being the vehicle of diffusion for animal parasites and many bacterial diseases.

CHAPTER IV

Alcoholic and Other Beverages

Wines, Beers and Spirits

The various forms of alcoholic drinks have played so large a part in relation to the health of the community that no treatise on food and health would be complete without some detailed consideration of these beverages. They can conveniently be classed into three main groups—wines, beers and spirits. All the varieties contain alcohol, which in every case is derived from chemical changes resulting from the action of certain lowly forms of vegetable life upon sugars of various kinds.

The frescoes on the ancient temples of Egypt reveal that the brewing of beer was an important and skilled industry in ancient Egypt many thousands of years ago, and indeed Herodotus ascribes its discovery to Isis. Ancient literature is full of allusions to alcoholic fermented liquors, while a good many of the legislative enactments of the Middle Ages are concerned with fraudulent practices in connection with such beverages and the means for their repression.

One of the earliest instances observed of chemical activity was the fact that solutions containing sugar, when exposed to the air, are liable to undergo considerable changes, resulting in the production of bodies containing new and striking properties when consumed. We now know that the primary change is a breaking down of sugar (of which chemically there are many kinds) into products of which ordinary alcohol and carbonic acid gas are the most conspicuous, and that these changes are due to the activities of yeasts. All the different kinds of sugar can be so acted upon, while there is a very large number of different kinds of yeasts, making the whole subject in its scientific aspects one of considerable complexity. Only a few of the salient points can be touched upon here.

Wines.—These are beverages in which the primary change is the alcoholic fermentation of the sugar naturally present in grapes. The grape juice, technically known as *must,* is chemically complicated, but contains a good deal of sugar, usually from 10 to 12 per cent., but no alcohol. The yeasts are naturally present upon the grapes, and are especially abundant when the grapes are fully ripe. The true wine yeast is called *Saccharomyces ellipsoideus,* but other yeasts are often present.

The crushed grapes are acted upon by these yeasts in fermentation vats, the naturally present yeasts being relied upon, but sometimes yeasts are

artificially added in the form of so-called "starters." The processes of fermentation will stop naturally when about 12 per cent. of alcohol has been produced, owing to alcohol in this strength inhibiting the further action of the yeasts.

In actual wine production numerous precautions have to be taken to prevent bacteria and wild yeasts from acting upon the wine juice and so producing unwelcome products, to see that a suitable temperature is maintained and that abundant air is present. In addition, various processes of the nature of refining have to be resorted to, while the wine has to be ripened. With dry wines, practically all the sugar is removed by fermentation, while with sweet wines enough sugar is left (or is subsequently added) to be perceptible to taste.

The final result is a liquid which contains the ordinary variety of alcohol (ethyl alcohol) up to 10 per cent. or less, a little sugar or none, according to the type of wine, and a very large variety of other bodies in small amount, such as other types of alcohol, various organic acids, and small quantities of carbohydrates.

Fortified wines are those in which alcohol, as distilled spirit, has been added in addition, sherry and port being the two best-known examples.

Malt liquors.—These include beer, ale and stout, and are obtained by the alcoholic fermentation of grain of various kinds, admixed with various flavouring and other substances.

Grain does not contain sugar, and the preliminary process is one of malting, in which part of the starch in the barley is converted into sugar, the ferment diastase in the germinating grain being utilised to perform this conversion. The process is stopped by boiling when carried far enough, hops being added at this stage. The conversion of the sugar in this liquid, or *wort* as it is called, is effected by a variety of yeasts. These, and also the temperature employed, largely determine the type of beer and the amount of alcohol present. The lager and other light German beers are produced by fermentation at a low temperature, and contain more sugar and carbonic acid but less alcohol than the beers mainly brewed in England at a higher temperature.

Beers (under normal conditions) contain about 3 to 6 per cent. of alcohol and also a little sugar, vegetable acids and various extractives.

Spirits.—In these beverages the alcohol and other volatile matters are obtained by the distillation of the products of the fermentation of bodies containing sugar, either as a natural constituent or derived from the conversion of some pre-existing starchy substance. Brandy is derived (at least in theory) entirely from the distillation of the alcohol from fermented grapes—i.e. is a distilled wine; whisky from the alcoholic fermentation of malt or malt and grain—i.e. is a distilled beer; rum from fermented molasses obtained in the manufacture of

raw sugar or from direct fermentation of the juice of the sugar cane; gin from fermented rye and malt, flavoured. They all contain a high proportion of alcohol (40 to 60 per cent.) and a number of extractives of various kinds, which give the distinctive flavour. They all improve materially as regards the latter points by being matured over a number of years.

Properties of alcoholic beverages.—From the point of view of the relation to health of alcoholic beverages, we must consider their properties as foods or as food adjuvants, the action of alcohol as a drug, and the broader question of their relation to health in connection with economic questions.

In considering their properties as foods we have to discriminate between the action of alcohol as such and the value of the other constituents contained in these beverages.

The chemical substance alcohol is undoubtedly a food, since it is burnt up in the tissues, and so supplies heat and energy, primary properties of food. Unlike most foods, it is absorbed unchanged into the blood—i.e. as alcohol itself, while it cannot be stored up in the tissues until it is wanted, like many other foods. Although it is burnt up rather rapidly in the tissues, yet this takes time, so that if new doses enter into the circulation before the previous ones have been destroyed the tissues are but seldom free from its presence and we find it acting as a poison.

As a food, its essential characters are its rapid absorption and the fact that such absorption is complete and unchanged, no preliminary digestion being required.

A further point limiting its utility as a food is the fact that as a drug it dilates the blood-vessels of the skin, causing a flush of blood to the surface, resulting in considerably increased loss of heat from the surface of the body, a loss which may more than counterbalance any gain of heat from the combustion of the alcohol itself.

While, therefore, we cannot but regard alcohol as such as a food, these facts severely limit its utility and make it quite unsuitable as a routine food to aid muscular or any other form of work. On the other hand, it has value as a food in certain emergency conditions when a substance is required which quickly yields up its heat-generating power.

As regards substances other than alcohol present in alcoholic beverages, it cannot be scientifically advanced that they have any material importance as sources of food. They are present in far too small quantities to furnish any considerable amount of nutritive material. The idea that beer, stout, wine or other forms of alcoholic liquors are valuable foods and useful as such to the body is a popular conception, but it rests upon no scientific foundation. The food value of the alcohol and of the other constituents in a pint of beer is only

about equal to that in three ounces of sugar, and it is supplied in a form which is far less useful than sugar to the animal body, quite apart from any question of its action as a drug.

The action of alcoholic liquors in relation to digestion is a subject upon which there is considerable difference of opinion. The Advisory Committee* appointed in 1916 by the Central Control (Liquor Traffic) Board to consider the effects of alcohol upon health and efficiency carefully weighed the evidence, and concluded: "Moderate doses have never been shown to affect appreciably the digestive organs apart from their taste and their tendency to increase the secretion of fluid and mucus from the walls of the stomach. On the other hand, there is a consensus of opinion that some of the alcoholic beverages may be more deleterious than others: wines which do not noticeably interfere with the digestion of one man may cause trouble to another." The latter feature they regard as due to the accessory substances and not to the alcohol itself.

Overshadowing completely its importance as a food is the fact that alcohol is both a drug and a poison. Its effects as such are well recognised, and any detailed consideration of them is beyond

* The Report of this Advisory Committee contains a careful and impartial account of the physiological action of alcohol in relation to its effects on health and industrial efficiency. It was published in 1918, by H.M. Stationery Office, under the title of "Alcohol; its Action on the Human Organism."

the scope of this book. The conclusions of the Advisory Committee need only be quoted in this connection. They are, that the main effects of alcohol that have any real significance are due to its action upon the nervous system and that this action is essentially sedative and is not really stimulant. "The popular belief in the stimulating properties of alcohol, as regards nervous and other functions, seems to be of purely subjective origin and illusory; it is, in the main, if not wholly, an effect of the narcotic influence of the drug, for, as we have seen, it dulls the drinker's perception of unpleasant conditions in himself and his surroundings, and may make him feel better, more efficient and stronger than he really is."

The other common effects of alcoholic consumption are narcotic in nature, due to the removal of the control exercised by the higher nervous centres. Acting through the nervous system, alcohol lowers functional activity, and as an aid to work, mental or muscular, is physiologically unsound. On the other hand, it is of value in certain contingencies. The general conclusion of the Advisory Committee is that the moderate use of alcoholic beverages is physiologically permissible only so long as it conforms to certain special conditions, these being as follows: (1) To avoid a continued action on the tissues, such an interval should elapse between the times when alcoholic beverages are drunk as will prevent the persistent

presence of a deleterious amount of the drug in the body. (2) To avoid direct injury to the mucous membrane of the stomach, alcohol should not be taken in concentrated form and without food.

The temperate consumption of alcoholic liquors, in accordance with the above rules of practice, may be considered to be physiologically harmless in the case of the large majority of normal adults.

To one looking at the subject from the Public Health standpoint, the feature of the alcoholic question which looms largest is not the amount of direct injury to individuals from the excessive use of alcohol, but the enormous wastage of money, by those who cannot afford it, upon alcoholic beverages. All investigators among the poorer sections of the community realise that no inconsiderable proportion of ill-health results from the diversion of money from the family income to alcoholic drinks, which do not furnish any material nutriment. This is a direct tax upon the food budget of the rest of the family, in innumerable cases reducing the income of the family available for food to a sum incompatible with the maintenance of adequate physiological vigour of all or some of its members. In this way alcohol is responsible for a material proportion of the ill-health of the community.

Some Non-Alcoholic Beverages

Tea.—In view of the heavy consumption of tea, it is important to consider how far this habit is detrimental to health. Tea-drinking in this country is of comparatively modern origin, and even up to a century ago the average consumption per head per year was only a little over 1 lb., compared to the present rate, which is five to six times that amount.

In relation to health, the only constituents of importance are caffeine and tannic acid. Caffeine belongs to the group of bodies known as vegetable alkaloids, and, like many other members of the group, is a powerful drug. In tea it is present in a percentage of 2½ to 4, varying with the kind of tea. It is very soluble, and is all, or practically all, dissolved out and present in the infusion as drunk. It is a stimulant to the nervous system, but cannot be considered harmful in moderate doses, its most prejudicial effect being exerted when tea or coffee is used, as is sometimes the case, by brain workers as an habitual stimulant to enable mental work to be performed which the brain without this stimulus would be unable to perform. Taken in habitual excess, tea may lead to a prejudicial stimulation of the nervous system.

More serious is its possible effect upon the digestive organs, to be ascribed in the main to the amount of tannic acid which it contains. This

substance is an astringent; as such it exerts a prejudicial action upon the stomach and other organs with which it comes in direct contact, and is one factor in the production of certain types of indigestion. The amounts present in tea infusions as drunk vary greatly, the two most important factors being the kind of tea and the length of time of infusion before it is drunk. Unlike caffeine, more is dissolved out with prolonged infusion.

Used with discretion and not in excess, and not consumed in a stewed condition, tea can be accepted as an advantageous addition to the dietary and as tending to healthy living. In stating this view we have to remember what tea replaced. Man does not take kindly to cold water as his habitual beverage; milk he regards as a child's drink and, with more reason, as a food, so that tea and coffee are largely substitutes for alcoholic beverages. For example, in the seventeenth century and earlier the drink at breakfast was ale or beer.

Coffee.—This is another comparatively recent importation, with much the same general characters as a beverage as tea; it is, however, far less drunk in this country. It contains the same alkaloid, caffeine. A cup of strong black coffee will contain about 1½ grains of caffeine and a certain amount of tannic acid. Its actions as a stimulant and as a cause of indigestion are much the same as those of tea, but, being so much less

used, it is not so commonly associated with that condition.

Cocoa.—This contains no caffeine, and the alkaloid theobromine, which it does contain, in amounts up to 2 per cent., has no stimulant action on the nervous system. In the main it is a harmless beverage, and although in itself not of high nutritive value, it ranks from this point of view above tea and coffee.

CHAPTER V

Milk and Milk Products

Of all foods, milk is most intimately and frequently associated with disease, and is the one which requires most care in its collection and distribution, but receives the least. This country has many sanitary sins at its door, but the least excusable is the one which has allowed our milk supply to become and remain to-day a disgrace and a scandal, in spite of the proofs—full, pressed down and running over—of the harm done which have been furnished by experts over a long period of years, and which no vested interest has been able to deny or to palliate. The ineffectiveness of the control over the production, transmission and sale of milk furnishes a striking illustration of the powers of vested interests to protect themselves at the expense of the health of the community.

Milk and disease.—The close association of milk with disease and ill-health rests upon the following facts and considerations:—

1. The animal supplying it may be diseased, so that the milk is infected at its source.

2. Milk is an ideal medium for the growth of bacteria, so that any danger from infection is magnified by the multiplication subsequently of the bacteria added.

3. Milk readily lends itself to chemical sophistication and impoverishment.

4. It is a food which to a large extent is consumed uncooked, and by children and other specially susceptible persons.

Composition of milk.—Being the secretion of a living animal, milk is both highly complex in nature and to some extent variable in composition. It contains all the primary chemical constituents of food mentioned in Chapter I., i.e. proteins, fats, carbohydrates, salts and water, while it also contains abundance of vitamines. These constituents are distributed in proportions not very different from those most suitable for the requirements of young and adult human life, but as regards cows' milk some adjustment of proportions is necessary to fit it for the delicate stomach of the infant and to make it conform in composition and physiological qualities to human milk.

Milk is fatally easy to adulterate, and, equally to the expert as to the man in the street, the addition of even a fifth or a quarter of water, or the abstraction of a considerable proportion of its cream, makes to the eye no detectable difference. Such alterations can be easily detected by the analyst, too easily in fact, since the very ease of

the manipulation allows the fraudulent milk vendor (a numerous tribe) to utilise analytical procedures to abstract cream or add skim milk or water in considerable amount and yet be within the legal standards.

The legal standard.—Cows' milk, in the eyes of the law, is the full, unaltered secretion from the udder of that animal, but in view of the variations in composition due to the character of the food given, breed of the cow and methods of milking, it is necessary to set up some chemical standards of composition, to fall below which is to create a presumption of adulteration, while milk that rises above it, even by the fraction of a percentage, is to be passed as genuine whole milk.

These standards are a proportion of fat of 3 per cent. and a proportion of solids not fat of 8.5 per cent. Taking the fat (cream) figure, the average composition of pure milk as collected at the farm is about 3.8 per cent., that of legally genuine milk as sold in many of our large cities is about 3.1 to 3.2 per cent. This means a loss of about one-fifth of the fat, one of the most important of the constituents necessary for the growth of the infant and the young child.

The existing enactments to protect the consumer from alteration in the chemical quality of milk are unsatisfactory, the fines inflicted are often ridiculously inadequate, and the profit from selling water at the price of milk is enormous.

Diseases of cows conveyed by milk.—While theoretically a number of diseases may be conveyed to man from the milk of cows which are suffering from disease, the only ones of any importance are tuberculosis, sore throat, food poisoning, and possibly undulant fever, usually called Malta fever.

Outbreaks of food poisoning are dealt with in Chapter VI., as they are so much more commonly spread by meat foods, but it may be mentioned here that in a considerable number of such attacks in which the vehicle was milk the outbreak was shown to be due to disease of the cow, the udder being infected with one of the food-poisoning bacilli.

Milk and undulant fever.—Undulant fever is a disease common in the Mediterranean area, caused by an organism called *Micrococcus melitensis.* Goats' milk is the common vehicle of spread, and this organism has been found in abundance infecting the milk of goats in Malta and other centres where the disease is always prevalent. The organism has been found in cows' milk, but is very rarely spread from the milk of that animal.

Milk and sore throat. — Outbreaks and isolated attacks of sore throat and other septic diseases spread through the milk supply are probably not uncommon, but the cause is frequently overlooked. A considerable number of outbreaks have, however, been recorded.

Milk and Milk Products

Cows fairly frequently suffer from inflammation of the udder, giving rise to the condition called mastitis or garget. This is always due to the action of bacteria, and may be set up by a good many different varieties, the majority belonging to the group known as streptococci. Cowkeepers are prone to regard this condition with far too little concern, classing it "as a little cold in one quarter" of no particular moment, and frequently allowing milk from such affected udders to be mixed with the rest of the supply and sold for human food. Fortunately only certain varieties of these streptococci are infectious and harmful to man, otherwise outbreaks of human disease from this source would be extremely prevalent.

As an illustration of such attacks, an outbreak in April, 1905, investigated by the writer, may be mentioned. At least 600 persons were attacked with symptoms of "septic sore throat," but fortunately there were no deaths. The outbreak was unmistakably spread by milk, since the infection picked out the houses supplied from a particular source and neglected the rest. The incriminated milk was derived from several farms, but most of the cases were on a milk round supplied chiefly from one of the farms, and its connection with the cases was further shown by the fact that a number of persons employed on that farm were also sufferers. Among the cows on that particular farm was one suffering from mastitis, the milk from

which was being added to the rest and sold throughout the outbreak, which only ceased when this animal was isolated and its milk not used. The mastitis was due to a virulent type of streptococcus, and the sore throat cases were of similar origin.

Milk and tuberculosis.—The disease caused by the tubercle bacillus is the most widely prevalent and fatal disease which affects civilised mankind. A considerable proportion of it is derived from the lower animals, and the relationship of tuberculosis to milk is of great importance.

Most of the domestic animals (the sheep being a notable exception) suffer from this disease, but from the point of view of direct infection to man the only species of importance are cattle and pigs. While tuberculosis in man may be set up by eating the meat of such animals, this source of infection is of far less importance than the consumption of tuberculous milk, partly because the latter is largely consumed raw, but also because it is the food of the young, who are peculiarly susceptible to infection through the digestive system.

Tuberculosis in the pig is believed to be contracted, in the main, from the ox through the milk of infected cows or from consuming the excreta of tuberculous cattle. Its prevalence varies greatly in different countries and in different parts of the same country. Quite broadly, its prevalence in this country varies from about 1 to 4 per cent. The disease

may be quite localised in certain parts of the body, or may be generalised and affect a number of areas.

The prevalence of tuberculosis in the ox and the cow cannot be stated as a definite percentage, since it varies not only in different areas but, to a marked degree, is influenced by age, the disease being far commoner amongst older animals. In calves it is rather infrequent, but in cows from 1 to 13 years old the percentage of tuberculous animals has been found to vary from 13 to as high as 70 per cent., rising steadily with age.

It is a very fortunate fact that not all such cows yield milk containing the tubercle bacillus. From this point of view we can group tuberculous cows into three classes.

The most dangerous are those which are affected with tuberculosis of the udder (mammary glands), since in all but the very earliest cases tubercle bacilli are excreted into the milk, and often in enormous numbers. The extent to which these animals occur varies greatly in different places, but roughly about 1 per cent. of all the cows in England are so affected. The condition is difficult to detect, and the cows frequently appear in good health.

The next most important group are the cows suffering from widespread advanced disease of many organs, because while the udder is not affected, in most instances the tubercle bacillus is

found in the milk. In this group the animals are obviously ill and cases are easily detected, while the number of bacilli present is less than when the udder is diseased.

The bulk of tuberculous cows belong to the remaining group, and these do not usually yield any tubercle bacilli in the milk. The group is nevertheless of great importance, since the animals infect others, while at any time such an animal may pass into one of the other groups. A few of them, indeed, do pass tubercle bacilli in the milk, and as they are well nourished such cases are most difficult to detect.

When ordinary mixed-milk samples are examined by the bacteriologist he finds the tubercle bacillus in about 8 to 15 per cent. of the samples, considerable variation with district being shown. It is probably a reliable statement to make that, in general, one out of every ten samples of ordinary milk as sold contains the bacillus of tuberculosis.

Bovine tuberculosis in man.—The extent to which human tuberculosis is attributable to infected milk and meat has been the subject of much investigation and has been fairly clearly defined. This is possible from the fact that the type of tubercle bacillus found in man is different from the type found in cattle and pigs, and the bacteriologist can distinguish the one from the other. While the human type cannot readily affect cattle, the bovine type (being the more viru-

lent of the two) unfortunately can and does attack man. Careful and painstaking studies of the types isolated from human cases have shown that while tuberculosis of the lung (consumption or phthisis) is rarely due to the bovine bacillus (less than 2 per cent.), a material proportion of cases of tuberculosis of other organs is due to infection with the bovine type, and therefore is of milk or meat origin.

Nearly all the cases of tuberculosis of bovine origin in man occur in children. Following the careful summaries of Cobbett, it may be said that about 18 per cent. of tuberculosis of the brain and its membranous wrappings, about 51 per cent. of tuberculosis of the abdomen, half to three-quarters of all cases of tuberculosis of the glands of the neck, and probably about 20 to 30 per cent. of tuberculosis of the bones and joints are of bovine origin.

These figures merely set out the proportions of the varieties of tuberculosis which are derived from diseased animals, but the actual extent can be obtained in another way, and Cobbett has calculated from the above figures that the mortality caused by infection with the bovine type *at all ages* is 6 per cent. of all cases of tuberculosis. This means that about 3,180 deaths per annum in England and Wales are due to tuberculosis of bovine origin, nearly all of which is from tuberculous milk, and practically all among children. If anything, experts would regard this as an understate-

ment. In addition, it takes no account of the amount of disease and suffering from these conditions which does not cause death. For instance, the majority of cases of enlarged glands in the neck of tuberculous origin are of the bovine type and are due to milk infections, but this condition rarely causes death.

Owing to the magnitude of the problem the difficulties in the effective control of tuberculous milk are considerable, while really two separate questions have to be considered. On the one hand the problem is an agricultural one, since the loss from tuberculous cattle is very heavy, and on economic grounds, quite apart from its connection with human disease, urgently calls for solution. It is also a Public Health matter, since much human infection is to be traced to this source.

The Tuberculosis Order, 1914.—Very little was done in the way of prevention until the Tuberculosis Order of 1914 was passed. After the War broke out this was suspended from operation, but from administrative and other reasons it was not a very efficient instrument. It aimed at limiting the amount of tuberculosis in cattle by providing for the destruction of two of the classes of tuberculous animals mentioned above—cows with extensive advanced tuberculosis and those with tuberculosis of the udder—as the chief distributors of infection. This was on right lines, but its value was largely nullified by its being worked solely as an agricul-

tural and not, as is absolutely necessary, also as a Public Health measure. As a measure to diminish bovine tuberculosis the Order, as it was being worked over large parts of the country, was, in the writer's opinion, a decided failure.

The whole question of tuberculosis in cattle needs to be tackled on broad lines. Not only must steps be taken to notify and get rid of the worst sources of infection to other cattle and the chief founts of tubercle bacilli in milk, but active measures are necessary to *find out* and destroy such animals. In other words, the preventive side of the problem must be developed, as it certainly was not under the Tuberculosis Order as administered, while at the same time farmers need to be encouraged and helped to build up herds of cows entirely free from tuberculosis, a procedure which is quite practicable.

The general public can do a great deal to bring about proper preventive steps merely by appreciating the need for and demanding milk free from tubercle bacilli. When such a public opinion is formed, farmers will find it worth their while to take the necessary trouble and care to meet the demand. The existing apathy of the public gives them no inducement to do so. At present the only safe thing is to *boil* all milk for children.

Contamination of milk originally pure.—The above remarks deal with disease originating with the cows themselves, but outbreaks of in-

fectious diseases spread by milk are more frequently due to contamination of the milk with the special germs of these diseases from sources outside the cow. Diphtheria, typhoid fever and scarlet fever are the conditions most frequently spread in this way.

Infection may be conveyed directly or indirectly. On the one hand, it may be derived from a person who conveys the germs either because he himself is suffering from the disease, is a living carrier of the germs (*see* Chapter III) in his throat or nose, or has the germs on his clothes from recent contact with a case. On the other hand, infection may be indirect, from contact of the milk with water, or with vessels, etc., which have become infected with the specific organism. These methods of infection will be made clearer if a few examples are given.

Diphtheria breaks out in the family of a cowkeeper who himself does some of the milking. The cowkeeper becomes infected, but owing to his natural powers of resistance either does not become ill at all or is so slightly attacked (a trifling sore throat with some malaise) that the nature of the affection is not suspected. He becomes a disease carrier with the living diphtheria germs growing in his throat or nose. Owing to absence of strict cleanliness some of the germs get upon his hands and so into the milk, or he coughs out diphtheria bacilli into the milk while he is milking. In the

milk these bacilli not only live but multiply enormously and infect not merely the one batch of milk but frequently other batches, either directly by the mixing of the supply or indirectly through contaminated milk vessels. The result is a widespread outbreak of diphtheria amongst the consumers.

In one instance (an actual outbreak) the woman in charge of a certain milkshop suffered from sore throat but took no particular notice of it and went on with her work, which included the handling and selling of milk. A few days later 40 cases of scarlet fever developed among the consumers of this milk, the outbreak only ceasing when she was removed to hospital. The fact that her sore throat was part of an unrecognised attack of scarlet fever was proved by the fact that she infected her two children a week after she was attacked, both of them developing undoubted symptoms of that disease.

In another outbreak 61 cases of typhoid fever suddenly occurred, all on the milk round of one dealer. The milk churns were washed by a man who was nursing a case of that disease. He was unclean in his habits, and very careless, and no doubt infective material from the person he nursed was conveyed by his hands directly into the churns and so infected the milk.

In general, it may be said that outbreaks of diphtheria and scarlet fever are more usually conveyed by direct infection from a human case or

carrier, while cholera, typhoid fever and dysentery may be so spread but are more often conveyed by indirect means such as water.

Many hundreds of such outbreaks have been recorded, many more occur but are not reported, and in a good number the source of infection is unrecognised. They still occur with considerable frequency.

Characters of milk-borne outbreaks.—Whatever the method of infection, milk-borne outbreaks are nearly always characterised by certain features, of which the following are the most important:

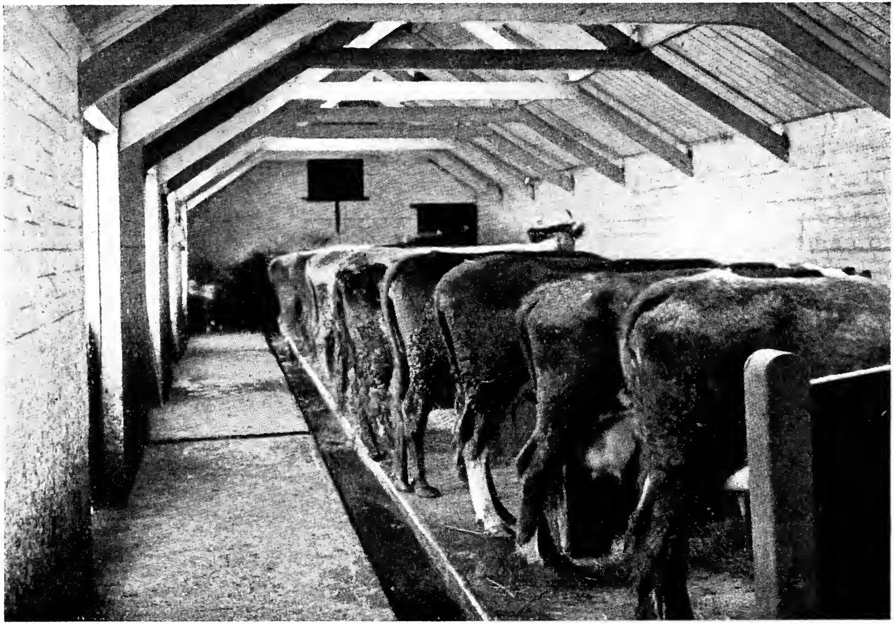
(*a*) The cases develop among those who drink a particular supply of milk. The houses invaded by the disease have a common milk supply, and usually nothing else in common.

(*b*) The outbreaks are explosive in character, that is to say, the bulk of the cases occur within a few days of one another.

(*c*) Those who are attacked are the milk-consuming part of the community. The richer classes, who drink more milk, are attacked in higher proportion than the rest of the community, children more than adults (unless the local custom is for the children to have their milk boiled).

(*d*) The milk drinkers in particular houses are attacked. Inquiries show that the sufferers are the milk consumers, while those who do not drink milk, or only drink it when cooked, escape.

There is yet another group of sources of con-

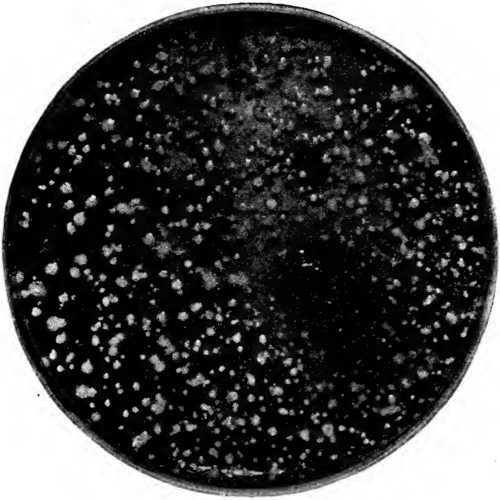


Manure-plastered cows in a shed with a good floor.

(From the Author's "Milk and the Public Health.")

PLATE III.

A



B

A.—Plate of solid nutrient material (agar) exposed for 15 seconds under the udder of a cow which had been groomed fourteen hours before milking.

B.—Similar plate exposed for the same period under the udder of a cow groomed about an hour before milking, the udder being washed with soap and water and left moist.

Each round white growth (colony) shows where one bacterium fell and grew, when incubated, into a colony. In A the number of colonies on this small area was 1,350, in B only 93, showing the enormous reduction effected by washing the udders.

(*From a Report by A. Lauder and A. Cunningham.*)

PLATE IV.

tamination, which is of great importance, and which may be spoken of as general bacterial contamination of milk.

How bacteria get into milk.—As sold in our larger towns, and in many of the smaller ones, milk frequently contains more than a million bacteria in each teaspoonful. Where do they come from, and does it matter if they are there?

Milk as secreted by the udder of the healthy cow is free from bacteria, but at every stage from the udder to the consumer contamination with bacteria is possible, and under many of the conditions which prevail to-day is invited. This will be very evident if we follow it in its passage.

During the milking operations the heaviest contamination is derived from the cow. It is very common, indeed in many districts it is almost the usual thing, at least in winter, to find the hind-quarters of the cow caked with partially dried manure (*see* Plate III.). The udders and teats are less obtrusively dirty, but they have only to be washed in water and the water looked at to demonstrate their filthy condition. During milking a good deal of this dirt gets into the milk. Mere simple washing of the udders and teats by unskilled persons will reduce enormously the number of bacteria added (Plate IV.); in several series of experiments it was reduced from about 4,000 to about 200 per cubic centimetre (a cubic centimetre is about half a teaspoonful). Confronted with

manure-caked cows, cowkeepers frequently complain of the impractability of keeping them clean. This is undoubtedly difficult under the conditions which are allowed to prevail so frequently. With floors not constructed of impervious materials and with the insanitary and dirty yards (*see* Plate V.) which surround so many cowsheds, undeniably it is most difficult to keep cows clean, but both these factors are easily remediable.

The dusty clothes of the milker, his dirty hands (for if they are clean to begin with they are filthy by the time he has milked two or three cows), the dust-laden air of the cowshed (*see* Plate VI.) all add their quota of bacteria to the milk. Another common source of bacteria is from imperfectly washed milk pails and milk churns.

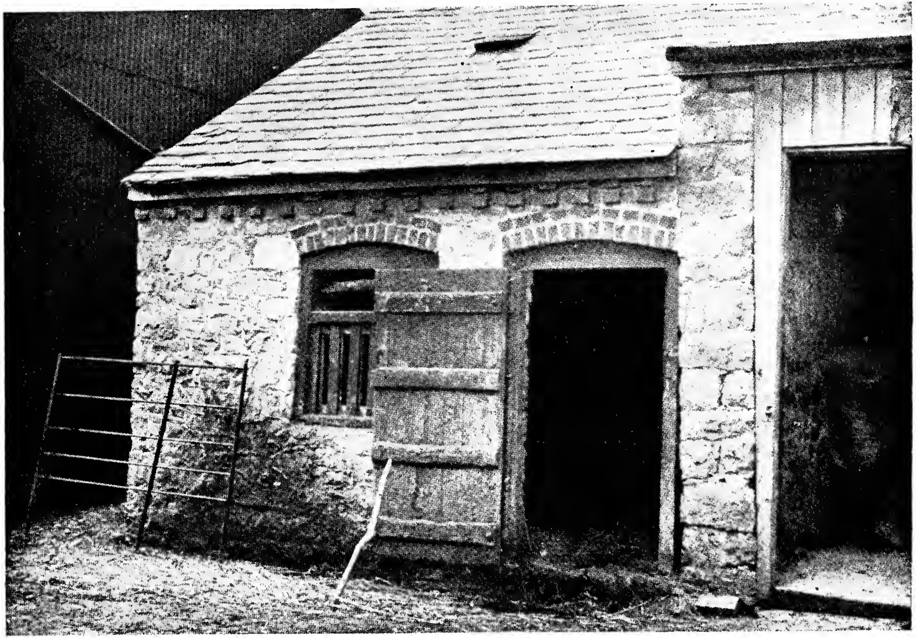
Frequently milk as it leaves the cowshed directly after milking will contain as many as 20,000 to 50,000 bacteria per cubic centimetre, and sometimes much higher figures are obtained.

Straining of milk.—The cowkeeper does not know much about bacteria, but he cannot fail to observe that particles of mud and other filth get into the milk, so he strains them out. He then thinks he has done all that can be reasonably required and that the milk is clean again. Straining milk is useless to remove bacteria, and milk after straining contains just as many as before, indeed it often contains more, since bacteria are often added from a strainer not kept scrupulously

Cowshed in which cows were milked, with a wall of manure just outside, and a foul pool of yard drainage and manure soakage.

(*From the Author's "Milk and the Public Health."*)

PLATE V.



Badly lighted and drained country cowshed from which tuberculous milk was sent to a large city.

(By courtesy of Dr. Hope.)

PLATE VI.

clean. From the Public Health point of view the straining of milk is not the slightest protection to it.

Contamination in transit.—In transit to the town more bacteria often get in from dirty churns to which it is transferred, from dust washed in by rain through the ordinary ventilation holes (which are not required), from mixing the milk at the railway stations, and in other ways. Considerable as this contamination may be, it is slight compared to that which takes place at the cowshed.

Contamination in milkshops and dwellings.—At stages further on many more bacteria obtain access—on the premises of the purveyor and the consumer, from the neglect of simple cleanliness, from dust, flies, unclean vessels, and the like.

Cooling.—As already explained, milk is a highly favourable nutrient material for the growth of bacteria, and those which gain access to it multiply greatly. Milk should always be cooled by passing it over a cooler or refrigerator, a simple and inexpensive apparatus which reduces its temperature by a stream of cold water or saline mixture. In many cases the milk is not cooled at all, or but imperfectly cooled. When it leaves the cow it is at the temperature of the animal, one which is particularly favourable to the rapid growth of bacteria, so they thrive and multiply enormously. Milk is frequently not received by the consumer until twenty-four hours after col-

lection, and in that time the bacteria may increase 10- to 100-fold or more, depending upon the temperature of the fluid. For example, in some experiments of the writer's, milk kept at the moderate temperature of 15° C. (59° F.) increased 2- to 40-fold, varying with the initial number, and when kept at 21° C. (70° F.), from 13- to 2,250-fold. When kept at freezing-point there was usually a slight decrease.

From the above it will be clear that the number of bacteria found in milk as purchased by the public will depend upon three factors — the cleanliness in collection, transit, and delivery, the time between the milking and its final sale, and the temperature at which the milk has been kept.

It is not possible, under ordinary natural conditions which could be carried out, to produce milk free from bacteria, but it is practicable to obtain and sell milk which, not having been manipulated, contains only a comparatively small number of bacteria. Practical milksellers have shown that this can be done at but small additional cost.

Milk and infantile mortality.—As regards the relationship of this dirty, bacteria-laden milk to disease, there is a large body of evidence proving that a considerable proportion of infant deaths are due to the consumption of impure milk. It is not possible, with our present knowledge, to say which

disease germs in the milk are severally and particularly responsible, though we can do this for some diseases, such as tuberculosis; but the facts which have been collected show that there is a very much heavier death-rate amongst infants fed with milk heavily contaminated with bacteria than amongst those fed with pure milk. The bacteria and their products cause diarrhœa and other conditions very fatal to the delicate infant body.

Why a pure milk supply is still to seek.—What should be done to give us a pure milk supply. Can it be done as a practical measure, and if so, why has it not been done?

The effective solution of the problem of tuberculosis in our herds, to begin with, is really a question of money. There is no doubt that tuberculosis can be banished from our cattle, but the expense of doing it all at once would be extremely heavy, and would cause such a tremendous dislocation of the milk-producing business as to make it impracticable. On the other hand, it has been explained that the chief danger to man is from two varieties of tuberculous animals, i.e. cows suffering from tuberculosis of the udder, and those suffering from advanced tuberculosis. Their rapid elimination is easily within the bounds of practicability, could be effected without either any great administrative difficulty or undue expense, and is a sound proposition if it is combined with steps steadily to build up herds free from tuberculosis.

What is chiefly lacking at the present time is a determination to face and solve the problem.

The protection of the community from the liability to outbreaks of acute infectious disease spread by milk is largely a matter of adequate supervision over those who handle milk, with compulsory notification to the local authority of all cases of illness among milk-producers and distributors.

The dangers of dirty milk can be obviated by a united demand for clean milk on the part of the community, and by their insisting that the causes of dirty milk, as indicated above, shall be removed. It is perfectly practicable to start with defined but moderate standards of cleanliness, and then make the worst offenders mend their ways by legal methods which will make the production of dirty milk unprofitable. When this has been effected the standards of cleanliness can be raised again, and once more the recalcitrant brought into line or eliminated as milk-producers. In this way, without any dislocation of trade, and with but little increase of cost, the quality of milk can be materially improved. The bugbear of increased cost is always trotted out to hinder such proposals, but the extra cost is not great, while dirty, infected milk is dear at any price.

Cleanliness at the source.—The place where improvement is particularly required is at the source of supply. Many well-meaning people who

want to improve the bacterial quality of the milk supply come forward with all sorts of devices (quite valuable in themselves) to effect improvement at the stages where they see the milk, i.e. in the milkshops, during delivery, and the like. These suggestions but touch the fringe of the trouble. It cannot be too strongly emphasised that the essential place of contamination with bacteria is during milking and on the cow-producer's premises, and it is cleanliness here that we must insistently demand. *A cleanly produced milk transmitted cool—these are the essential requirements to give us clean milk;* the other things are comparatively minor matters.

Palliatives.—Pasteurisation is a palliative, not a cure, and has only a limited, though valuable application. Sterilisation by domestic boiling is a very wise precaution in view of the prevailing conditions, but this again is only a temporary and local palliative.

Grading.—The grading of milk according to its quality, with different prices according to the grade, is advocated by many, and is useful, especially as a temporary measure; but milk is too important to child life to allow the mere possession of money to determine who shall have it pure, and leave dirty, manure-laden milk for those whose purses cannot afford the better quality. Grading of milk has the great merit that it demonstrates to the milk-producer, as nothing else

will, that the bacterial quality of the milk is of material importance, and that bacterially good milk will command a higher price than milk loaded with bacteria. It is educative and useful, and there is much to be said for its adoption as a temporary expedient, if it is accepted as a means, and not as an end in itself—a step towards the production of a safe milk supply.

The kind of standards which are aimed at in milk-grading will be clear from the following recommendations as to the grading of raw milk made by the American Commission on Milk Standards:

"The Commission believes that all milk should be classified by dividing it into three grades.

"*Grade A.*—Milk of cows free from disease, as determined by tuberculin tests and physical examination by a qualified veterinarian. Milk produced and handled by employees free from disease, as determined by medical inspection of a qualified physician, under sanitary conditions such that the bacterial count shall not exceed 10,000 per cubic centimetre at the time of delivery to the consumer.

"*Grade B.*—Milk from cows free from disease, as determined by physical examination, of which one each year shall be by a qualified veterinarian, and produced and handled under sanitary conditions such that the bacterial counts at no time exceed 1,000,000 per cubic centimetre.

"*Grade C.*—Milk from cows free from disease, as

determined by physical examinations, produced under conditions such that the bacteria count is in excess of 1,000,000 per cubic centimetre.

"They suggest that if local conditions are such that it is necessary to allow the sale of *Grade C* milk, its sale shall be restricted to cooking and manufacturing purposes."

Ignorance and heedlessness of the consumer.—The above statements as to the contamination of milk and the practicability of avoiding it are not new; they are the commonplaces of the expert, given without thanks and without reward to those who sit in places of authority, and we may well ask ourselves: Why are these things still so? Primarily, I think, because the average consumer does not know and does not care. The idea that his milk may have been depleted of its cream will sometimes throw the householder into a white heat of indignation against his dairyman, with beneficial results as regards the future fat-content of his milk, but the fact that he and his consume countless hordes of bacteria, which certainly should not be there, moves him not at all, for he does not know of their presence, and if he did would not comprehend their significance. With this prevailing apathy it is, perhaps, not to be wondered at that the powerful interests which surround the milk-producer have successfully resisted reforms, so that very little real progress is being effected.

Having studied the milk question for over sixteen years, the writer has reluctantly to state that things are only improved, if at all, to a trifling extent. The existing legal powers are inadequate in themselves, and largely inoperative as regards the sources of supply, since the authorities who administer them are chiefly composed of members who either themselves produce milk or who are intimately associated in business relationship with those who do.

It may, perhaps, be advanced that these remarks are to a considerable extent assertions, and that the proofs are not given. They cannot be given in the space available here, but all who want such proofs can find them elsewhere.*

The new Milk Act.—It will be said that there is a Milk Act upon the statute-book, only waiting to be put into operation when after-war conditions become more normal, and that the effect of this Act will be to put everything right. While it is decidedly a valuable measure, it will only go part of the way towards effecting what is required. It will be remembered that this Act resulted from an "agreed" Bill, i.e. one to which there was no opposition of any importance in its passage through the Houses of Parliament.

In legislation, of a Public Health character at any rate, it will generally be found that an agreed

* *See* "Milk and the Public Health," by the present author. Macmillan and Co. 1912.

Bill takes the following course. The promoters and drafters of the measure, who know what is needed, frame a Bill which does give a satisfactory measure of effective control. To get it passed as an agreed measure they then have to compound with each vested interest sufficiently powerful to endanger the Bill in Parliament, either by removing from it many of its essential clauses or by allowing "safeguards" to be inserted which in their effect either make the clauses largely unworkable or so slow in operation that they fail to do much good. The Bill then becomes an Act, and both sides have a measure of satisfaction, the one because it has succeeded in obtaining improvements, possibly material improvements, in the existing laws, and much official experience has taught the philosophy that some crumbs are better than no bread; the other because, though it has given up a good deal, yet it has obtained a respite for years from any more legislation affecting its vital interests. An "agreed" Act, in the sphere of Public Health, is rarely a thoroughly efficient instrument.

Milk Products

Condensed milk.—Condensed milk is milk from which the greater part of the water has been removed, and is prepared either from whole milk or from separated milk, i.e. milk which has had its cream removed. Sugar may or may not be added,

so that four varieties are possible; but only three appear to be put upon the market—i.e. condensed whole milk, sweetened and unsweetened, and sweetened condensed separated milk.

Very large quantities of condensed milk are used. For example, in 1909 as much as 991,378 cwt. was imported into the United Kingdom, and a very great increase has taken place since that date.

Various methods of preparation are employed, but the usual procedure for the sweetened varieties is to take the fresh milk, pasteurise it by heating to 80°-85° C., or even higher, and then add cane sugar to about 14 to 15 per cent. of the weight of the milk. The milk and sugar is then placed in large copper vessels (vacuum pans) connected with powerful suction pumps and surrounded by coils of steam pipes. By exhausting the air a partial vacuum is caused, while the chamber is heated by the steam pipes. The milk boils at a quite low temperature (about 50° C.), and the water is removed by the pumps. In this way the water is got rid of and the milk thickens. The process is stopped when the milk has become of the correct density, a point ascertained by drawing off trial samples. The viscid milk is run out into cylindrical vessels, cooled by cold water, the milk being stirred constantly. When cold the milk is transferred to tanks and filled into the tins, which are then closed.

The preliminary pasteurisation kills most of the

bacteria present, but a certain number gain access during the subsequent manipulations. As a rule, these are harmless in nature, and do not multiply in the unopened milk, owing partly to the absence of air but chiefly to the inhibition of growth by the high proportion of cane-sugar present.

The unsweetened condensed milks are usually prepared by heating the milk to a higher temperature (100°-113° C.) than that used for the sweetened, the heating being done under pressure. After the milk is placed in the tins they are subjected to a further sterilisation. This is necessary since the absence of cane-sugar leaves the milk a fairly suitable medium for bacterial growth, in spite of its viscid nature.

All varieties of condensed milk may become "blown" and unsound owing to the development of gas due to the activities of organisms. With the unsweetened variety this is most likely to be due to putrefactive and other bacteria, but with the sweetened types the commonest cause of blowing is the action of yeasts, there being few other organisms which can grow in the presence of so much cane-sugar. With these sweetened milks there is no sterilisation after canning, so that if the strictest cleanliness has not been observed a considerable proportion of a given batch may be infected with yeasts during preparation, become blown in consequence, and be rejected by the food inspector as unfit.

These foods are extensively used in infant feeding, but to their use for this purpose many valid objections can be raised. Even when the whole-milk varieties are chosen they are apt to be deficient in fat as fed to infants, since to dilute the sugar sufficiently so much water has to be added that the fat-content is brought down dangerously low. The sugar also is apt to disagree. The brands made from skim-milk are entirely unsuitable, as they do not contain sufficient fat, while their thick appearance is liable to deceive the ignorant mother into thinking she is using a nourishing article. All such brands should be conspicuously labelled as not only made from skim-milk but also as unfit for infant feeding.

Condensed milks have the advantage that they contain far fewer bacteria than fresh milk, and are not likely to spread tuberculosis or other infectious disease.

An important drawback to their use is the fact that although the tins may contain few bacteria before being opened, they are usually large enough to last for a number of days, and the bacteria which gain access from dirty spoons, flies, dust, etc., survive, and to some extent multiply. In this way condensed milks have undoubtedly played an important part in the spread of outbreaks of infantile diarrhœa, an infectious disease responsible for a very large number of deaths amongst infants in the hot summer months.

Milk and Milk Products

These forms of food are chiefly of service as a convenient emergency supply for adults.

Dried milk.— Dried milk is the powder obtained either by passing milk rapidly between heated surfaces so that it is deprived of its water, or by drying on a cylinder in a partial vacuum. A number of special methods are employed with small variations from these general methods.

Dried milk is used to a considerable extent in connection with the preparation of certain foodstuffs, such as milk chocolate, sweets, milk bread, and biscuits. These are all legitimate uses, but the same cannot be said of its use by dairymen to add to fresh milk, either to make up a temporary shortage, or to fortify a milk fraudulently reduced as regards its fat-content to below the legal 3 per cent.

Apart from trade purposes, dried milk is used for ordinary domestic consumption, when fresh milk is not obtainable, and for infant feeding. Its use for the former purpose is not so satisfactory as might be thought likely, since it does not readily and completely dissolve in water and reconstruct milk. It is difficult to get a uniform mixture, while the taste is different from that of milk, even of boiled milk. Different brands show considerable differences in this respect, while the solubility seems to decrease with the age of the samples. No doubt these defects will be overcome in time.

As regards its use in infant feeding, dried milk is markedly superior to condensed milk, and is free from most of the objections of the latter. The different brands contain very few bacteria, and those present are nearly always harmless; but, if prepared without due care, tubercle bacilli present in the original milk may survive. Added bacteria do not multiply, although they may live for some time.

In view of the extensive use of dried milk in infant feeding, much discussion has taken place as to whether the methods of preparation destroy the natural vitamines (*see* p. 13) of the milk. The evidence is not altogether consistent, but it would appear that some vitamines remain, although the total amount is diminished.

The results of feeding infants with dried milk of different kinds are highly satisfactory, and it is particularly useful for this purpose in the hot summer months. The milk reconstructed from dried milk has the advantage that the clots formed when it meets the acid stomach juices are smaller than those which occur with fresh cows' milk, so that the dried milk is frequently better borne and better digested. There is undoubtedly a considerable future for milk in this form, both for infant feeding and for adult use.

Butter.—Butter is an interesting example of a food the final form of which is largely due to the beneficent activities of bacteria. The cream, after

churning, is subjected to a process of ripening, butter being the resulting product. The changes which constitute ripening are due to bacterial action, and the commercial value of any butter is largely determined by the flavour so produced.

In the older methods these fermentative changes were partly caused by the original bacteria in the milk and cream, and partly due to the action of the air of the dairy and creamery. Being uncontrolled, there was considerable liability to contamination with undesirable bacteria, which adversely affected the flavour and quality of the butter.

Most butter is now prepared by the addition of pure or nearly pure cultures of the bacteria which cause these changes. They are added as "starters," and are prepared and sold commercially. The activities of any abnormal bacteria are prevented by a preliminary pasteurisation of the butter. These starters consist of different varieties of lactic-acid bacilli, and are of quite a harmless nature.

It will be apparent that ordinary butter contains vast numbers of bacteria; indeed, often as many as ten to forty millions per gramme, nearly all being of the lactic-acid bacillus type. The number of bacteria materially decreases with keeping; but as they are quite harmless, the number present is immaterial.

Butter is not of great importance as a source

of disease from bacterial contamination. Organisms such as the typhoid and tubercle bacilli artificially added to butter will live for considerable periods, but no outbreaks of acute infectious disease have been traced to this food.

The extent to which butter samples naturally contain tubercle bacilli varies greatly, and results as high as 15 per cent., or even more, have been recorded, but in some of the most recent English results the percentage infected was under three. The danger of tuberculosis resulting from butter is probably not great, and this can be obviated by making the butter from pasteurised cream only, as explained above.

Margarine. — Although not a dairy product, margarine, being a substitute for butter, can most conveniently be considered here. It is made from vegetable and animal fats with suitable flavouring, and mixed with some milk.

If made under clean and satisfactory conditions margarine, from the point of view of bacterial infectivity, is a very satisfactory product. It is as nutritious as butter, while it is absorbed nearly as well. Physiologically, the only way in which margarine may be considered inferior to butter is in the fact that the fat-soluble vitamines appear to be absent from vegetable fats, while any present are destroyed in the manufacture. Vitamines are, therefore, absent from margarine. In view of the fact that margarine or butter forms such a small

part of the total dietary, and that necessary vitamines are readily obtained from other sources, this fact appears to be of no great practical importance.

The very extensive substitution of margarine for butter in the dietaries of both the poor and the well-to-do does not seem to be fraught with danger to health; on the contrary, it is probably a material advantage, as leading to an increased consumption of fat from the lessened cost, and as enabling more milk to be sold as milk, instead of being converted into butter.

Cheese.—The changes which occur in cheese-ripening appear to be partly chemical, partly bacteriological, the latter being more particularly concerned with the processes which give the different flavours. The number of bacteria in cheese is always large, but varies with age. While abnormal bacteria may be present and cause changes which damage the cheese commercially, these organisms are not prejudicial to health.

Cheese is probably very rarely a means of spreading bacterial disease. Tuberculosis might possibly be so spread, but there is no evidence of actual cases. On the other hand, one extensive outbreak of typhoid fever has been traced to cheese as the probable cause.

Ice-cream.—As made in this country, ice-cream usually consists of milk and sugar, with a thickening agent such as cornflour, and with or without

eggs. Flavouring agents, and often colouring matters, are added, while gelatine is sometimes used in the manufacture. Cream, as such, and apart from milk, is not used. The mixture is always heated, then cooled, and subsequently frozen.

The essential points are that these constituents form a food highly nutritive for bacteria, that ice-creams are often compounded from materials already heavily infected with bacteria, that they are heated but not sterilised, that the cooling is natural and therefore prolonged, and that the subsequent freezing does not kill any of the harmful bacteria which they may contain. When it is added that the vendors, as a class, are inefficiently educated in the importance of cleanliness, and that the places where they prepare and store their materials are often most insanitary, it is not to be wondered at that ice-cream, as sold frequently, contains millions of bacteria to the teaspoonful. A good many outbreaks of infectious disease, such as typhoid fever, and illnesses of rapid onset like food-poisoning, have resulted from infection from ice-cream.

Very careful supervision of the preparation and sale of this variety of food is required.

CHAPTER VI

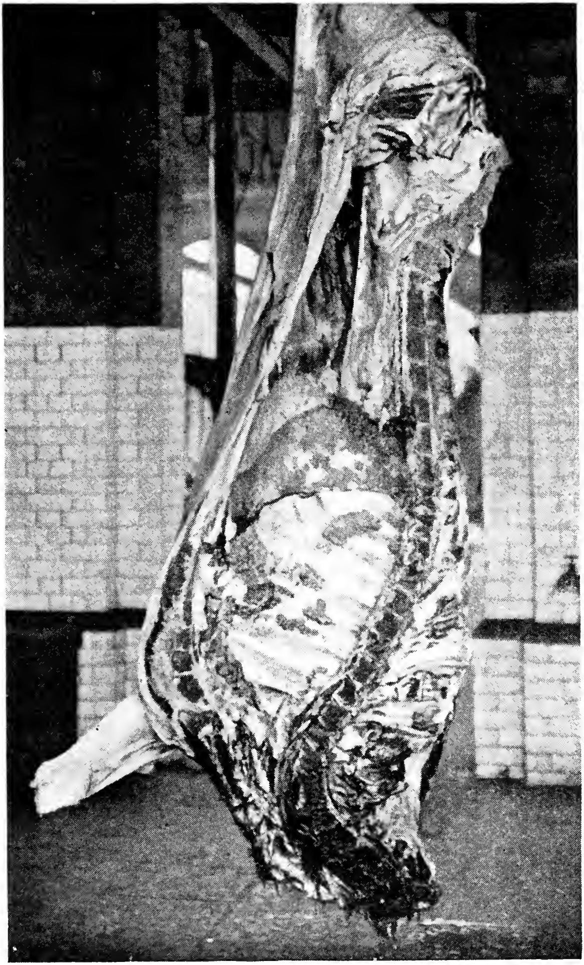
Meat Foods

MANY of the bacterial diseases from which the lower animals suffer are peculiar to them and are not shared by man, but a considerable number are common to both. While theoretically those diseases which also affect man may be conveyed by the consumption of the meat of animals so infected, in practice the diseases so transmitted are comparatively few. The explanation is that for a good many of them the method of infection is not, except in extremely rare cases, by way of the digestive system. This is true, for example, of such diseases as rabies, glanders, foot-and-mouth disease, and tetanus (lockjaw). Man can suffer from all these diseases, but infection almost invariably occurs through the inoculation of wounds or tiny abrasions in the skin or the mucous membranes, the latter being the delicate linings of the mouth, lips, and other parts of the body communicating with the exterior.

In other diseases, such as anthrax, the meat is highly infective, and would infect man if it were eaten; but the animals attacked die very quickly,

with severe and definite symptoms, so that there is small likelihood of the flesh being sold for food. Anthrax of intestinal origin (i.e. derived from food) is of extreme rarity, and infection almost invariably occurs either through the skin, or through the lungs from inhaling the dust of rooms in which hides of animals dead from this disease are sorted. The disease called actinomycosis is fairly common in cattle, especially affecting the tongue and jaw, and may possibly be conveyed to man by food. Indeed, this condition has been detected in ox tongues from Argentina put upon the market. Definite cases in man of infection through food have not, however, been recorded, although occasionally man is infected with this disease.

Apart from disease due to animal parasites, which are dealt with at the end of this chapter, the only conditions of any importance conveyed by the flesh of infected animals are tuberculosis and bacterial food poisoning. In addition, there is a group of animal diseases of the nature of septicæmia and pyæmia, due to the bacteria which cause abscess formation and suppuration, and giving rise to these conditions in animals; they are a menace to man, not so much because the consumption of the meat may produce these diseases (although this is possible), but because the diseases are associated with rapid decomposition of the meat. Such meat quickly spoils and allows outside bacteria to infect it, so that



Part of carcass of ox, showing patches of tuberculosis-growth in lower half.

PLATE VII.

secondary changes take place, either putrefaction or more defined infections, which render the food unfit to eat and a danger to health.

Tuberculosis from meat.—Tuberculosis is the most important disease conveyed from domestic animals to man. It was explained in Chapter V. that this condition is very common both in the ox and in the pig, and may be transmitted to man from the consumption of the meat of these animals. On the whole, the danger of acquiring tuberculosis in this way is not very great, for three reasons. One is because adults, who are the chief meat eaters, are not very susceptible to infection with the organism of tuberculosis through the digestive tract, much less so than children. A second reason is because this disease in infected animals can be fairly readily recognised (Plate VII.), and meat in a badly infected condition is not likely to be put upon the market. The most important reason is that meat is only eaten when cooked.

It is true that the figures given elsewhere dealing with the temperatures reached in cooking show that the interior temperature of large masses of meat does not rise very high, and indeed in the middle of even moderate-sized joints the tubercle bacillus would probably not be killed, but those on the outside and for some depth from the exterior would be destroyed. The bacilli are not implanted in large numbers in the middle of masses of muscle,

most of them being in glands and other tissues near the surface, so that in actual practice the majority are killed during the cooking process. While therefore the danger of infection from the meat of tuberculous animals cannot be neglected, it is comparatively insignificant compared with that which we know exists from milk contaminated with the tubercle bacillus.

Disease may be conveyed not only by meat derived from a diseased animal, but also, and much more frequently, by meat originally sound but infected with harmful bacteria after the slaughter of the animal.

Growth of bacteria in meat.—Meat, like milk, is an excellent medium for the growth of bacteria. If a few harmful bacteria gain access to meat by any of the methods discussed farther on, they usually find conditions which satisfy all their requirements, and then they increase enormously in number. The rate of increase is markedly influenced by the temperature, but even at such moderate temperatures as 55° to 60° Fahr. (13°-15° C.) such bacilli may increase many hundredfold in twenty-four hours, and many thousandfold in forty-eight hours. This very materially increases the danger of disease being transmitted.

The digestive juices can usually be relied upon to kill out a few harmful bacteria and prevent their surviving and passing into the blood stream, and

Defective private slaughter-house (now closed), of fairly common type.

(By courtesy of Dr. Hope.)

PLATE VIII.

so setting up disease, but when they are present in large numbers sufficient of them may escape destruction to cause infection.

It is this multiplication of bacteria in milk and meat which makes these foods so much more dangerous as agents for the spread of infection than bread, cereals or vegetables, which do not favour bacterial growth.

Infection in the slaughter-house.—It is important to consider when and how foods become infected from outside sources. At the slaughter-house itself heavy contamination may occur. The carcasses should not be left to cool and set in the killing-room, but should be transferred at once to a room, clean and sanitary, kept specially for the purpose (*see* Frontispiece). This is not done in one out of a hundred private slaughter-houses. The animal is dressed and then the carcass is slung in the same room as where slaughtered, and where other animals immediately afterwards are killed. (Plate VIII.) Anyone familiar with slaughtering under such conditions will realise the likelihood of infection from direct handling by the slaughtermen, by splashing from the subsequent operations on other animals, and by general infection from dust. Since the carcasses are at nearly body temperature and cool slowly, any bacteria which have gained access will be provided with very suitable conditions for multiplication.

In quite a number of cases gut scraping is

carried on in the same slaughter-house. This is a set of processes involving the cleaning out of the intestines of the animals, washing them, soaking them for long periods in salt solution, and ultimately using them for catgut or sausage skins. Inasmuch as the intestinal contents are crammed with bacteria, some of which are likely to be harmful if the animals are not healthy, while some splashing of the contents is hardly avoidable, a more dangerous and horrible practice to carry on in a slaughter-house is difficult to imagine.

Often enough sausage-making and the salting of meat are carried on in the single-room slaughter-house, and the sausage meat and the salted meat may be contaminated from splashing during slaughtering. Usually the contaminating bacteria are not harmful, but it is largely a matter of luck whether or not they are. It is indeed a fortunate circumstance that we prefer our food cooked.

Infection transmitted by rats and mice is probably of more importance than is generally realised. These animals sometimes suffer from bacterial diseases transmissible to man, as well as from the animal parasites described later on, while in old slaughter-houses and other premises where meat foods are handled they are frequently very prevalent. They may contaminate and infect carcasses by their excretions, and so convey disease, but there is little information available as to how far infection is actually spread in this way.

Meat Foods

Prepared meat foods.—While animal carcasses may be infected by any of the methods described, the kinds of meat food most liable to bacterial infection are the class of made-up meat foods, such as brawn, meat pies, sausages, and the like, and it is desirable clearly to understand why this is the case.

In the first place, there is a temptation to compound such foods from meat of inferior quality, the makers trusting to the condiments added and the alterations which take place in preparation to disguise this inferiority. It is, for example, considerably more difficult to detect inferior quality meat, or meat of foreign origin such as horse-flesh, when used in sausages or meat pies than when vended in the form of joints or large pieces of meat.

In the second place, such forms of food are subjected to considerable manipulation in the course of preparation, and if these processes are not carried out with scrupulous cleanliness at each stage there is the likelihood of bacteria being added to the food from unclean hands or utensils, from dust, by flies, etc. This danger is increased by the fact that the preparation processes are often only carried out after the meat has been put aside for some time, thus allowing the contaminating bacteria to multiply.

A further source of danger arises from the partial heating to which many of these foods are subjected. In itself this might appear to give

protection, since harmful bacteria will be killed during the cooking. This often occurs, but not always, since frequently the degree of heat reached, a matter regulated by the commercial objects to be attained and not by Public Health considerations, is not high enough to sterilise the central parts of the food (meat pies, for example), while gravy and other constituents are sometimes added after cooking. Also, this advantage is largely discounted by the fact that the meat has to be cooled again, and cooled slowly, which means that the meat, an admirable nutritive material for bacteria, is maintained for many hours at temperatures which are just those suitable for bacterial growth. If, therefore, such made foods are put to cool in surroundings where they can become infected, their bacterial contamination may be very heavy.

It is an extraordinary and discreditable fact that legislative powers for dealing with the preparation of such foods are trifling and quite inadequate. Under existing conditions it is common to find these made-up foods manufactured and cooled in most unsuitable premises and under most unsatisfactory conditions. The larger businesses, which make a feature of such prepared meat foods, are usually considerably more satisfactory than the smaller places, where they are but adjuncts to other trades, but unhygienic arrangements are very prevalent generally.

No one should be permitted to prepare made

foods except upon premises which have been inspected and approved and which are then licensed annually by the Local Sanitary Authority. Such authorities should also be required to frame and enforce by-laws for the regulation of such premises.

The part played by flies and infected dust as agencies in conveying bacterial infection to food has already been insisted upon (Chapter III.).

Sanitation of restaurants, etc.—It may be mentioned here that there is need for very much more supervision and control over the sanitary arrangements of restaurant kitchens and other places where food is prepared on a considerable scale. If would-be diners could inspect some of these places before they dined their bills probably would be smaller and some of them would go empty away. But often what the eye does not see the stomach does not revolt against.

Food poisoning.—The public reads from time to time in the newspapers accounts of deaths from so-called ptomaine poisoning, and every now and then is startled by reports of extensive outbreaks of illness, sometimes affecting hundreds of persons, due to poisoning from some article of food consumed in common by all the patients. These outbreaks and cases are far more numerous than would appear from the papers, or even from the medical journals, for only a small proportion are ever reported.

Up till comparatively recently their cause and origin was obscure, but our knowledge of their nature is now fairly complete. At first they were thought to be due to meat which had undergone decomposition, and when some fifty years ago certain investigators isolated from decomposed meat a number of poisons which were called *ptomaines* it was supposed that the poisonous symptoms were due to these bodies and the condition was called ptomaine poisoning, a designation which is still adhered to although it is quite erroneous and misleading. Ptomaines are chemical bodies formed late in putrefaction and when the meat would be far too nasty to eat, and they have nothing to do with the case. In fact, in almost all the outbreaks the erring food eaten is perfectly natural in appearance, taste and smell, and there is not the slightest evidence of putrefaction.

Food poisoning is really due to bacterial infection and is caused by several types of micro-organisms, but all the important outbreaks are due to one or other of two bacilli—i.e. *Bacillus enteritidis* and *Bacillus suipestifer*. These two bacilli are very nearly identical with one another and with the organism which causes paratyphoid fever. All three are allies of the typhoid bacillus. The so-called ptomaine poisoning is therefore bacterial, not chemical, in nature, and is spread like other bacterial diseases by infection with a particular organism, in this instance through food.

Meat Foods

While the vehicle of spread is usually some form of meat, this is by no means always the case. Of 112 British outbreaks studied by the writer, 90 were spread by flesh foods, 9 by milk, 6 by ice cream, and the remaining 7 by other media, including potatoes, cream, and fruit jelly. Of those spread by meat foods, 11 were from fish (4 fresh, 7 tinned), and 37 from brawn or meat pies. The most noticeable point was the fact that in two-thirds of the cases the food was prepared or made up in one form or another (brawn, meat pies, tinned, etc.), while in many of the remaining third the food was stuffed meat, or prepared in one way or another. The large proportion of outbreaks associated with made-up foods is to be ascribed to the special handling and other sources of infection of such foods, as already described.

Careful investigations have shown that several of the animals used for food, notably the pig and the ox (including the cow and calf), may suffer from diseases due to these special bacilli, and that outbreaks of food-poisoning have in a number of instances resulted from the use of these diseased animals for food or from using the milk of infected cows.

In other outbreaks the evidence clearly shows that the food was infected after slaughter, and that the animals supplying it were perfectly healthy. In these cases the most probable explanation is that the healthy meat was infected from animals

which were diseased or were bacterial carriers, through the splashing of their intestinal contents in slaughter-houses, or by infected utensils, or by flies or dust. In this way vegetable foods also, such as potatoes, may be infected.

A peculiarity of these two food-poisoning bacilli, and one which fits in with their special association with these outbreaks, is the fact that the poisonous substances they produce as the result of their growth (toxins) are very resistant to heat, and can withstand the temperature of boiling water for more than half an hour. This means that if they have had time to grow in or on the infected food for some time they will have produced toxins which will still give rise to symptoms of food-poisoning even after the food has been thoroughly cooked. Outbreaks due to these chemical toxins alone may result from tinned food, all the bacilli having been killed in the process of sterilisation.

The usual history in outbreaks of food-poisoning is that a number of persons, ranging from a family to a whole section of the community, consume a certain food, and after an interval, which may be only a few hours or as long as 30-40 hours, a large proportion of them are taken ill, usually with the same group of symptoms, of which marked vomiting, violent and continued diarrhœa and severe abdominal pains are the most conspicuous. Death may occur, but most patients recover after a few days.

It is usually fairly easy to trace the food which has been eaten in common, and if the bacteriologist is promptly consulted he can generally trace the organism concerned, but it is not always easy to say how the food became infected.

These outbreaks are far more prevalent in the summer than in the colder months, but they occur all the year round.

As regards putrefactive changes as a cause of poisoning from food, it is probable that the danger of such food has been exaggerated. We do not know enough, however, in regard to the changes which occur, and the bacteria which cause them, to be able precisely to measure the danger. Certainly, even slightly tainted or putrefied meat swarms with bacteria, and should not be allowed to be eaten as food.

Botulism.—A variety of food-poisoning of quite another type, called botulism, occurs occasionally in America and on the Continent, but there are no cases recorded in this country. The symptoms are quite different and are rather striking, involving the nervous system and the eyes. It is due to another kind of food-poisoning bacillus, and only occurs when the food has been stored under conditions which do not allow free air access. The so-called cases of botulism in England in 1918 were examples of a quite different disease, and had nothing to do with botulism or any form of food-poisoning. The widespread adoption of the

term botulism for these cases furnishes an illustration of the fascination of a definite and attractive label for a disease, and the difficulty of rectifying an error perpetrated in haste and without due consideration of all the factors.

Animal parasites.—In this country the disease-producing rôle played by animal parasites in food is not a large one, but they are of considerable importance in tropical countries and amongst communities where food is imperfectly cooked. The most important are certain kinds of tapeworm and a little worm called *Trichina spiralis.* Only three tapeworms are of any importance in this country, and all three require, or prefer, two animal hosts for their development, the adult worms living in one and the larval or embryo forms in another.

Two of the adult worms, *Tænia solium* and *Tænia mediocanellata,* occur only in man, while the larval forms occur respectively in the pig and the ox.

T. mediocanellata is the largest of the human tapeworms, and may consist of more than 1,000 segments, with a total length of over 20 ft. The head of this tapeworm has four powerful suckers but no hooklets. The parasite fixes itself by means of the suckers to the intestinal wall, the worm living in the small intestine. Each segment contains male and female organs, and the number of ripe segments containing mature eggs at any one time may be at least 200. The ripe eggs are

discharged into the intestine and are passed with the excretions. They do not undergo further development unless they can gain access to the digestive system of the ox, hence the enormous number of eggs which are produced on the chance that some will reach the desired haven. In the ox the eggs develop into larval forms, which pass through the intestines into the muscles of the ox, where they remain enclosed in envelopes or cysts, known as *Cysticerci bovis*. When they are numerous they cause a peculiar appearance in the meat, which is known by the very inappropriate name of measly beef. When such infected meat is eaten the larval forms are set free, develop into adults, which in turn attach themselves to the wall of the intestine and continue the cycle.

T. solium is smaller than the ox tapeworm, with rarely more than 800 segments. The small head has well-developed suckers and also a ring of hooklets. It lives in the small intestine of man, and its life history is very similar to that of *T. mediocanellata*, except that the corresponding bladder-worm, *Cysticercus cellulosæ*, is chiefly found in the muscles of the pig, causing measly pork, and infection is derived from eating such infected pork. Occasionally the bladder-worm stage occurs in man, as well as the adult form, infection resulting from the eggs.

Both *T. mediocanellata* and *T. solium* may cause ill-health, the latter being the more danger-

ous of the two, since both stages may occur in man.

Prevention depends in part upon proper disposal of the human excretions, and in part upon efficient meat inspection and thorough cooking of meat foods.

Man may also be infected from another tapeworm, *Tænia echinococcus,* but in this case the adult worm lives in the intestine of the dog, while it is the capsulated larval form which affects man, giving rise to the condition known as hydatids. These may be very dangerous, as, unlike other encysted larval forms, they may increase indefinitely in size, with many secondary cysts.

This tapeworm is a very small one, being about one-fifth of an inch long, and has only three or four segments. The head has suckers and two series of hooks by which it fixes itself in the intestine.

The infection is derived direct from the dog, or indirectly through drinking water contaminated by these animals. Sheep and other animals used for food may also be infected from the dog.

Another important tapeworm, *Bothriocephalus latus,* is rare in this country, but is not infrequent in countries bordering the Baltic. The adult form occurs in man, producing very severe anæmia, and is conveyed through eating fish. The larval form is found in various fresh-water fish, especially pike and perch, and when such infected fish is

eaten the larval form develops into the adult worm in the human intestine.

Trichinosis is a disease due to a roundworm, *Trichina spiralis,* which has caused many outbreaks in Germany, but is uncommon in England. Its prevalence in Germany is due to the extent to which pig is eaten in a raw or insufficiently cooked condition. The parasite occurs embedded in the muscles in a larval form, surrounded by a thick capsule. If pork so infected is eaten without the parasite being killed, the capsules are dissolved by the stomach juices and the larvæ are set free and pass into the intestine, where they develop, and in two or three days grow into the adult worm. The female adults produce many hundreds of larval forms, and these, often by the thousand in severe cases, penetrate through the intestinal wall and get into the blood stream and are carried to the muscles, where they encyst themselves. These changes in the muscles give rise to fever and severe muscular pain. The adult forms disappear in five to six weeks, but the encysted larvæ remain alive for many months.

When many of these parasites pass into the muscles death may occur, the average mortality being about 5 per cent., but it has been much higher in some epidemics. One of the worst epidemics in Germany involved over 300 persons, of whom nearly a third died. While man is attacked from infected pork or other pig meat as just

described, the pig itself is infected from diseased rats, or by the offal, etc., of other pigs. Unlike the tapeworms, the whole cycle of changes can occur in the same animal.

It is not practicable to detect trichinosis in pigs during life. The method mainly employed for its detection after death is the microscopic examination of small pieces of muscle taken from the areas most commonly selected by the parasite; but this procedure is not a particularly satisfactory one. The number of pigs affected varies greatly in different countries, and roughly is from 1 to 5 per cent. The best method of prevention is to eat pork, sausages, etc., only when thoroughly cooked, since a temperature of about 70° C., or rather less, kills the parasite.

CHAPTER VII

Foods of Vegetable Origin

WHILE foods of vegetable origin are not a source of much disease, they cannot be altogether ignored. Plants, like animals, suffer extensively from bacteria which set up diseases; but while these conditions are of great economic importance, fortunately none of them can originate these or other diseases in man. The only plant conditions which are known to be a menace to man are certain gross parasitic diseases, of which ergotism and lathyrism are the only important examples.

Ergotism.—Ergot is a vegetable parasite, a fungus, which attacks grain, usually but not exclusively rye grain. This parasite, *Claviceps purpurea,* replaces the grain and appears as a brownish-red growth. Bread made from such diseased rye is intensely poisonous, its potency depending upon the proportion of the rye which is diseased. Ergot is a valuable drug, and contains definite poisonous chemical bodies which, while invaluable in definite doses as a medicine, have caused appalling outbreaks when consumed as bread made from diseased rye flour.

Outbreaks of ergotism, as the disease is called,

only now occur in Russia, but in medieval Europe epidemics were very widespread and extremely fatal. The condition was, no doubt, exaggerated by the bad social conditions and insanitary surroundings of the peasantry, and especially by their chronic underfeeding. Outbreaks, involving thousands of persons, a large proportion of whom died, were common in certain parts of Europe. The sufferings of the patients were terrible, and the disease remained quite uncontrolled until social conditions improved and its cause was recognised.

Lathyrism.—In certain parts of India, and to a lesser extent in Italy, France, and Algeria, a somewhat analogous condition called lathyrism is met with. It occurs in man as a chronic nervous disease, with cramps and paralysis of the lower limb muscles, due to the habitual use as food of the peas of certain species of vetches (*Lathyrus sativus, Lathyrus cicera,* etc.). The symptoms appear only after the peas have been eaten for some time, and this varies greatly. A striking feature of every epidemic is that men are much more affected than women, generally at least 10 to 1. Lathyrus peas are eaten by large numbers of mankind, and it is only when they form an excessive part of the diet that cases occur. When the peas are the sole diet the disease may appear in six to eight weeks. The symptoms are due to the formation of chemical poisons of the nature of vegetable alkaloids.

Foods of Vegetable Origin

Bacteria and vegetable foods.—Like milk, meat, and other foodstuffs, foods of vegetable nature may serve as vehicles of infection carrying harmful bacteria and possibly animal parasites. Vegetable are much less likely than animal foods to act so, partly because they are less handled in course of preparation, but mainly because these harmful bacteria do not, in general, multiply on such material, and are readily washed off.

Bread is a good illustration of this point. Any bacteria which may be in the flour derived from human handling, contamination by rats or other animals, etc., are nearly all killed in the process of baking. There is, however, the risk from handling bread. Careful experiments have shown that bread handled by dirty persons or without care will contain on the crust far more bacteria than bread handled with care or sold wrapped in paper. It will be obvious from what has been said in Chapter III. that bread handled by an infective person may serve as a vehicle for carrying pathogenic organisms; but inasmuch as such bacteria will not increase in numbers, the likelihood of infection spreading in this way is not very great. Cases of typhoid fever in a hospital for the insane at Washington have been traced to the fact that the attendant, who cut the bread as his first duty in the morning, had been taking care of a typhoid fever patient in his home.

The excreta of animals and sometimes of

human beings are extensively used to manure soil in which vegetables are grown, and it has been suggested that in this way typhoid and other harmful bacilli may contaminate cabbages and other green vegetables and so spread these diseases. While this is a possible cause, it is a most unlikely one. To complete the chain of infection, the typhoid bacilli must be present (they do not live very long in excreta and, of course, are only there if derived from affected persons), they must infect the vegetables, there they must survive light and sunlight, and later the washing to which most vegetables are subjected, and finally they must withstand the cooking.

Watercress.—The only green vegetable food which is likely to act as a vehicle for the spread of enteric fever is watercress, because it is sometimes grown in water contaminated with sewage matters and because it is eaten raw. In several outbreaks there has been a strong suspicion that the cause was contaminated watercress. Careful and thorough washing of the cress very materially reduces the risk, but the essential condition is a pure source of supply.

"Ropy" bread.—While the bacterial diseases of plants are not harmful to man as far as is known, some of the conditions which affect such foods, particularly when manufactured, make the food unsaleable, and so are of some economic importance. The so-called "ropy" or "slimy" bread

is a good example. The condition is due to a harmless spore-bearing bacillus (*Bacillus mesentericus*), which gets into the materials of the dough. Being highly resistant, the spores are not killed in the baking, but grow and cause the bread to darken and have a peculiar taste and odour. After three or four days the bread becomes ropy or slimy, and can be pulled out into strings. The bacillus is a common soil organism, and usually gains access as a contamination of the yeast. Once introduced it may be difficult to get rid of. Other varieties of undesirable bacilli may make bread acid, due to the formation of lactic or butyric acid.

As regards acute poisoning from foods of vegetable origin, those, such as mushroom poisoning, in which the harmful bodies are naturally present have been considered in Chapter I.

Infected potatoes.—It has been explained that outbreaks of food poisoning may occur from infection of vegetable as well as animal foods with the special bacteria associated with those diseases. In a number of instances potatoes have been the vehicle, so much so that the condition is sometimes separated off and called "potato poisoning" as if it had a special causation. These outbreaks associated with potatoes were at one time thought to be due to an excessive amount of the alkaloid *solanine*, which is naturally present in potatoes, and which under special conditions (e.g. when sprouting) they may contain in large amount. This

is probably not the true explanation, at least in most cases. In nearly all the outbreaks the potatoes have been peeled overnight, and in this condition they are a splendid nutrient material for bacteria. The outbreaks are mostly due to these exposed potatoes, unprotected by their skins, being infected with the food-poisoning bacillus just as meat or brawn is infected.

The only other way in which vegetable foods may be injurious is from admixture with harmful chemical substances added either intentionally or by accident. Chemical preservatives are added to some beverages but are not required for most foods of vegetable origin. These and such accidental additions as arsenic in beer and lead in cider have already been considered in Chapter II.

Adulterated vegetable foods.—The adulteration of vegetable foods is largely a question either of the substitution of a cheaper food of a lower nutritive value for one that is more nutritious and dearer, or the addition of chemical substances to improve the appearance of the food and enhance its commercial value.

It is important to realise to what a considerable extent food-faking occurs, and flour (bread) may be selected as an excellent illustration.

Faked flour.—Wheat flour is used for bread because of the high proportion of the protein substance gluten which it contains. In bread-making the yeast or other gas-producing substance used

causes the flour-and-water mixture, when baked, to rise into a spongy mass, which only remains so because the gluten becomes viscid in the process. Other cereals, like rice, maize and barley, do not contain gluten in sufficient amount and so cannot be used for bread-making. Although such a simple process, it offers many opportunities for substitution or adulteration. While bread cannot be made from rice, potatoes, etc., alone, these things can be added to wheat flour up to a certain proportion. In the English war-bread, potatoes were added up to 10 per cent. or more. This addition implies the substitution of a substance of a lower nutritive value. When the substitution is publicly admitted, and only added for a specific purpose, such as eking out an insufficient supply, it is legitimate enough, but when done clandestinely to make money it obviously is a fraud.

The modern taste for white bread has caused millers to prepare and sell white flour prepared by rejecting the darker outer parts of the wheat grain and only grinding up the white interior parts. In this way a very white fine flour is obtained. Actually it is of lower nutritive value than the flour prepared from the whole grain, but it contains fewer mechanical particles. The value of their removal is problematical, because although possibly irritating to a few sensitive persons, for most consumers these coarser particles are beneficial by

acting as a stimulus to the intestine, preventing constipation.

Many persons considered that war bread disagreed with them and caused indigestion, but most medical men found that there were very few genuine cases, and the majority were probably due to the influence of suggestion. Certainly there was nothing chemically injurious in war bread, and any ill effects could only be due to mechanical properties such as the presence of grit, diminished porousness, etc. Where complaints were genuine they could generally be traced to insufficient milling and incorrect baking.

Millers, however, have not been content to produce a white flour obtained simply by the rejection of the outer parts of the grain, but the higher price of the white brands has led to the *artificial bleaching* of flour. The method most in use is to bring the flour for a short time into contact with a gas called nitrogen peroxide. A lower grade flour when bleached will be whiter and therefore commercially more valuable. The evidence as to how far this practice is prejudicial, from the chemicals (nitrites) introduced into the flour, is not very conclusive, but it would appear that it may be harmful, apart from the substitution of a lower for a higher grade of flour.

Yeast is used to make the bread rise solely because it yields carbonic-acid gas. Owing to the inconvenience and sometimes the uncertainty of its

action, chemicals which yield the same gas are often substituted and so-called baking powders have been evolved. Ordinary baking powder consists of sodium bicarbonate and an acid substance such as tartaric acid, cream of tartar or acid calcium phosphate. The alkali and the acid, when mixed with water, yield the same carbonic-acid gas as is obtained from yeast. Self-raising flour is merely flour containing these essential elements of baking powder added to it.

These chemical substances are harmless enough, but the addition of chemicals always involves the risk that those used may not be pure. This is a likely contingency, because it costs money to purify chemicals, and so there is a temptation to use impure chemicals. That is exactly what does happen.

Instead of the original cream of tartar, something cheaper is used, i.e. acid calcium phosphate. This latter substance, as ordinarily made, contains considerable amounts of calcium sulphate (plaster of Paris). When made with care it only contains 2 to 3 per cent., but it has been found with as much as 50 per cent., and this in acid calcium phosphate used in a baking powder. The calcium sulphate is at least useless, and possibly harmful.

Worse contaminations than this may be present, for at one time large batches of baking powder made from acid calcium phosphate were found to contain considerable quantities of arsenic, derived,

as explained in Chapter II., from the impure sulphuric acid used to make the phosphate. Besides these adulterations, substances called *flour improvers* have been introduced. They consist of chemicals which are usually added to the flour in the proportion of 1 to 2 lb. to each sack of 280 lb. Chemically they consist of phosphoric acid, acid phosphates of calcium, potassium, magnesium, etc. The improvement seems to be confined to the finances of the vendor, the claim as to their value being that more bread can be obtained per sack of flour from their use, i.e. the "strength" of the flour is improved. This result can, of course, only be achieved by retaining more water in the bread. Reduced to its financial elements it means that the small extra cost of the "improver" is balanced against the sale of a certain quantity of water at the price of bread. Even if it be granted that the chemicals used in the improvers are harmless in the pure state, there is the same risk as in the use of baking powders—that harmful chemicals may be added as adulterants. They do not improve in any way the value of the bread as a food.

Examples from other foods might be given, although less striking. They show how extensive is the prevalence of food-faking and how insidiously poisonous or prejudicial chemical substances may be introduced by what appear to be at first sight quite harmless additions or substitutions.

CHAPTER VIII

Shell-Fish

THE relationship of shell-fish to disease is very instructive, and affords many valuable illustrations of the ways in which food may serve as a means of spreading disease to man. We can recognise all the three groups of disease or ill-health which have been mentioned in connection with some other food:

1. The shell-fish may be wholesome but disagree with certain individuals.

2. The shell-fish may be diseased or unsound and so cause acute poisoning.

3. The shell-fish may be sound and wholesome but may act as a vehicle for bacterial infections.

It is well known that shell-fish, and especially mussels, at any time of the year may disagree with certain individuals and set up eczema, nettle-rash, digestive disturbances, etc. This clearly is due to an idiosyncrasy in the individual, and is part of the condition of special susceptibility mentioned on p. 23.

Apart from such idiosyncrasies, there are many persons who find that shell-fish disagree with them,

possibly owing to their indigestible nature, as in the case of crabs and lobsters.

It is also widely accepted that oysters should not be consumed out of season, and disagree if so eaten, but it is not clear whether this is due to bacterial changes in the oyster favoured by warm weather or to reproductive changes.

These conditions, however, while of moment to the individual, are of no great general importance, and do not give rise to outbreaks of disease.

Poisonous mussels.—Mussels and other shell-fish have occasionally been associated with an acute type of food-poisoning. In these cases the symptoms come on rapidly after the consumption of the mussels, usually within a few hours or less. They are of a rather peculiar character, such as prickly sensations in the hands and feet, constriction of the mouth and throat, difficulty in swallowing and speaking, numbness about the mouth and general muscular weakness. These are all symptoms pointing to changes involving the nervous system, while they are often associated with the vomiting, diarrhœa and abdominal pain characteristic of ordinary outbreaks of food-poisoning. Death frequently occurs; for example, out of 63 cases in six different outbreaks, 10 were fatal (16 per cent.).

The actual cause of the condition is not clear. In one outbreak in Germany (Wilhelmshaven, 1885) a very poisonous body called mytilotoxin

was isolated and was believed to be the cause, but there is considerable doubt as to the correctness of this view. Probably the poisonous properties are due to chemical poisons of unascertained nature formed from the growth of harmful bacteria in the mussels and derived from their being grown in contaminated water, as in harbours or docks. It has been shown that non-poisonous mussels become poisonous when placed in polluted waters, while poisonous mussels kept in clean, pure, running water rapidly become harmless. Outbreaks in recent years have been rare, so that the obscurity as to the cause has not been cleared up.

"Green" oysters.—An interesting condition sometimes met with in oysters is that which is indicated by the expression "green" oysters. The green coloration is due to several causes; it may be harmless in nature, or, as in some of the Cornish oysters, it may be due to copper. This, however, is only present in very small amount, and a considerable number of such oysters would have to be consumed to set up symptoms of poisoning. The condition, therefore, is not of much practical importance.

Shell-fish and bacterial infections.—The chief significance of shell-fish in relation to disease lies in the fact that they may passively convey infectious diseases to man. This applies mainly to oysters, cockles and mussels, and the diseases so

spread are typhoid fever and, far less frequently, cholera and possibly dysentery.

Oyster-beds.—The adult oyster is sedentary, and obtains its food not by pursuing it, but by drawing the food to itself. The shell gapes a little, and by means of fine processes called silia, which vibrate very actively, a current of water passes in between the shells and through what is called the mantle cavity of the oyster. Here the water undergoes a process of straining fine enough to retain particles as small as bacteria, while the water itself passes through. These particles furnish the food of the oyster. In a very pure water the oysters do not get enough nourishment, and it is a matter of common knowledge that oysters flourish best in esturial waters, which contain considerable solid matter, and that they grow very well indeed when the particles of such waters are augmented by sewage. Commercial instinct unchecked by Public Health control will naturally, therefore, select sewage-contaminated estuary waters as the best for oyster cultivation, since they yield the fattest and most marketable oysters.

All these estuary waters contain many bacteria, and all oysters contain bacteria, but if the water which feeds the oysters is pure all the bacteria will be harmless. If the water is sewage-polluted, then the oyster will strain out the sewage bacteria and the number of these sewage bacteria in the oyster will be roughly proportional to the dilution of the

sewage with pure sea water before it is sucked between the valves of the oyster. The bacteriologist can and does measure the extent to which shell-fish are exposed to sewage contamination by the number of the most readily recognisable types of sewage bacteria which he finds in the shell-fish.

The above facts explain why so many oyster-beds have been placed where sewage pollution occurred and sometimes where it was very gross, and it has required a number of sharp outbreaks of typhoid fever to enable Public Health officers and departments to get a sufficient backing from public opinion to suppress the dangerous oyster-beds.

Because sewage bacteria get into the oyster it does not follow that such shell-fish must cause typhoid fever or other infectious disease, since the ordinary sewage bacteria are comparatively harmless. If they are present in any numbers it shows that such oysters are dangerous, because oysters from these sources may *at any time* be infected with harmful types of bacteria. This important fact explains how it is that oysters from sources known to be definitely and constantly exposed to heavy contamination from sewage may be eaten over long periods without demonstrable harm resulting and then quite suddenly give rise to a severe outbreak of typhoid fever. Sooner or later the sewage which pollutes an oyster-bed will receive typhoid bacilli from the excretions of patients or of unrecognised

typhoid carriers. It is then a matter of chance, depending upon the numbers of typhoid bacilli and the degree of fouling of the oysters, whether the typhoid bacilli are sufficiently numerous to reach and infect the oysters. These bacilli can remain alive both in oysters and in sea water or tidal mud for a short time (about two weeks), but they do not appear to multiply under these conditions.

Another source of contamination arises from the fact that a large proportion of oysters are not sold direct from the beds but are taken up and relaid for some months in fattening beds—artificial pools washed by tidal waters, and these are frequently so situated as to be exposed to sewage contamination.

Oysters and typhoid fever.—As a typical example may be instanced the outbreaks of typhoid fever at Winchester and Southampton in 1902, following the mayoral banquets in those towns. At the Winchester banquet there were 134 guests, of whom 9 contracted enteric fever, besides one waiter; at the Southampton banquet there were 132 guests with 10 cases and also one attendant. In both cases many others of the guests (44 at Southampton) suffered from acute digestive and intestinal disorders of varying degrees of severity. Careful inquiry showed that the only item in the menus capable of explaining the outbreaks was the oysters. Both lots of oysters were from the same source, and were consumed in both towns on the

same day, and in other towns in which a number of typhoid fever cases occurred oysters obtained from the same source were also consumed the same day. The oysters were all derived from beds which seven years previously had been reported as liable to gross pollution. They were laid down within a few yards of the main sewer of a town, a town in which cases of typhoid fever had been unduly prevalent for years, and in which several cases had occurred shortly before the outbreaks here described.

As we have seen, infected oysters, if placed in pure water, will get rid of harmful bacilli and become innocuous again. How long this takes depends upon several factors, but about two weeks appears to be a safe interval.

The oysters themselves do not appear to be adversely affected by the bacteria, but act purely as passive agencies of infection. As they are mostly eaten raw, there is no protection from cooking.

To prevent infection from contaminated oysters the use of beds liable to heavy sewage pollution must be prohibited, and all oysters of suspicious origin must be purified by a sojourn for a sufficient period in uncontaminated sea water. Considerable powers to these ends are available under the Public Health (Shell-fish) Regulations, 1915.

Cockles and mussels.—These shell-fish have similarly given rise to cases of enteric fever, but

so far as the writer is aware they are not associated with other infectious diseases. Being distributed and sold in small quantities, they rarely give rise to extensive outbreaks; but there is no doubt they have caused many individual cases. Both cockles and mussels are, for the most part, found in or near estuaries, and are therefore liable to sewage pollution in the same way as oysters.

Cockles, unlike other shell-fish, are subjected to some measure of cooking after collection; according to the cockle-gatherers they are boiled, but really they are exposed to only a low degree of heat, which affords very incomplete protection. Where efficient sterilisation has been practised the cockles may be regarded as safe, whatever their origin.

INDEX

Index

Index

Index

Index

Index

Index

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